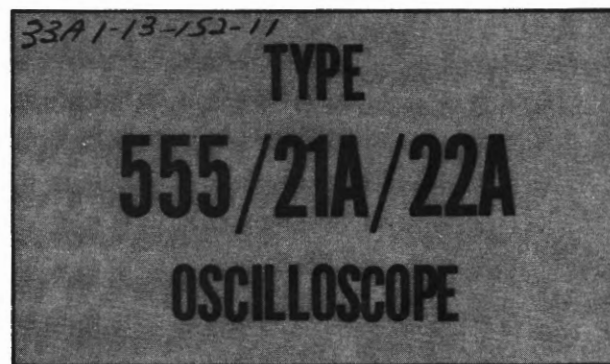


INSTRUCTION MANUAL

Serial Number _____



Tektronix, Inc.

S.W. Millikan Way • P. O. Box 500 • Beaverton, Oregon 97005 • Phone 644-0161 • Cables: Tektronix
070-403



WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

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Tek # 555

T.O. 33A1-13-152-11
18 September 1968

IDENTIFYING TECHNICAL ORDER

This ITO replaces ITO 33A1-13-152-11, dated 1 July 1968, and the commercial manual.

1. PURPOSE. This technical order is issued for the purpose of identifying and authorizing for official use a commercial publication identified as follows:

CONTRACTOR--- Tektronix

COMMERCIAL NUMBER--- Type 555/21A/22A

TITLE--- Instructions with Parts Breakdown - Oscilloscope

DATE--- Not dated.

ADDITIONAL IDENTIFICATION: Copyright 1964

2. FILE LOCATION. The above listed commercial publication is filed in

3. SUPPLEMENTARY INFORMATION. The information contained in the above listed commercial publication is supplemented as follows for official use.

Manual Change - Modification Insert, Type 555, Mod 101D, Copyright 1966

Reference Page 1-1, Table 1-1: Delete the risetime of "14.5 nsec" and add "16 nsec" for the Type 1A1 plug-in over the calibrated deflection factor 0.005 to 0.05 v/cm.

Delete the passband "dc to 24 mc" and add "dc to 23 mc."

Delete the risetime of "23 nsec" and add "24 nsec" for the Type H plug-in.

PUBLISHED UNDER AUTHORITY OF THE SECRETARY OF THE AIR FORCE

This technical order issued by SAAMA (SANST)

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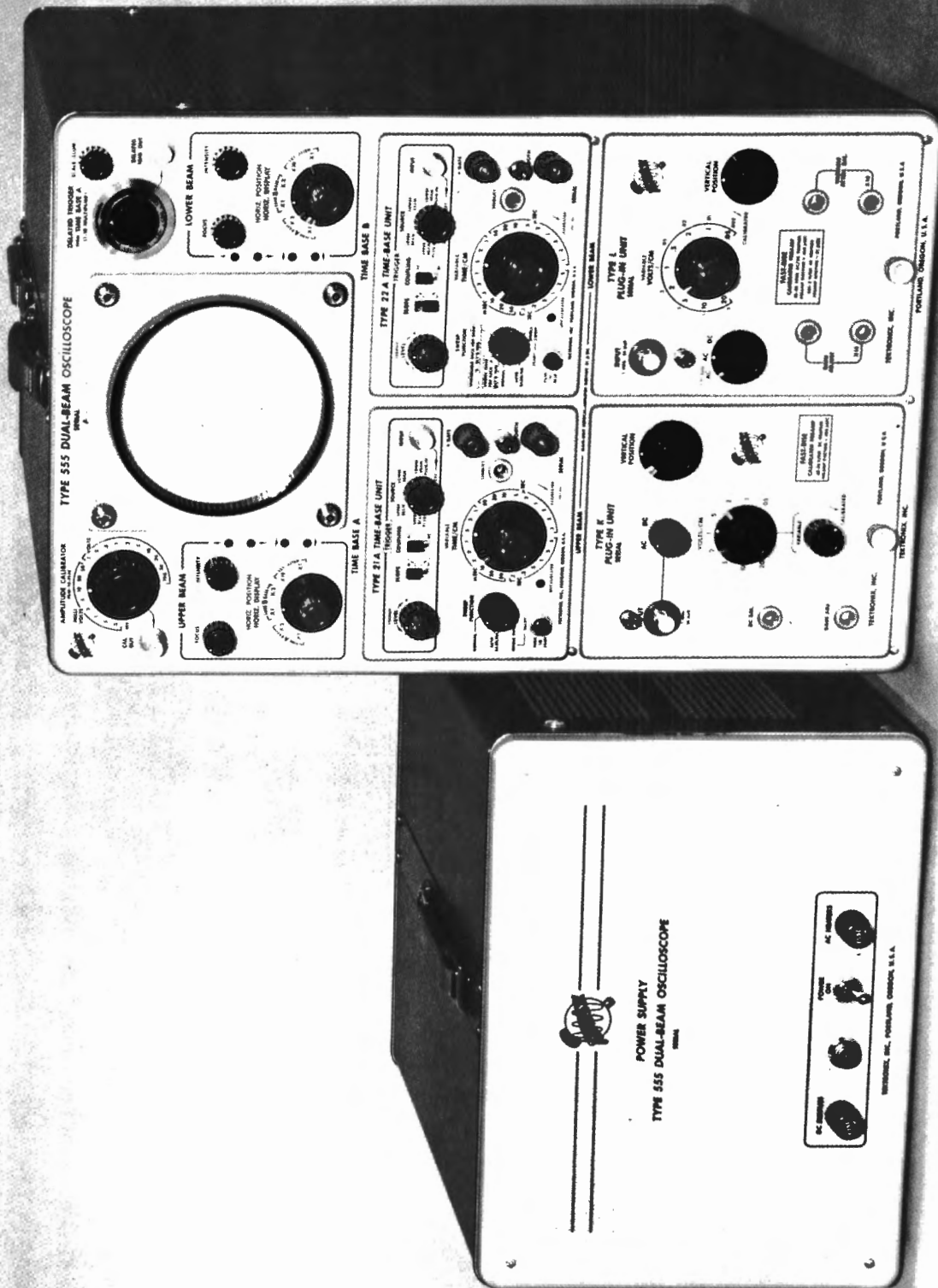
Section 4 Circuit Description

Section 5 Maintenance

Section 6 Calibration

Section 7 Parts List and Diagrams

A list of abbreviations and symbols used in this manual will be found on page 7-1. Change information, if any, is located at the rear of the manual.



SECTION 1

CHARACTERISTICS

NOTE

The following characteristics are for the Tektronix Type 555 Oscilloscope (S/N's 7000 and above) with Type 21A and Type 22A Time Base units.

GENERAL INFORMATION

The Type 555 Oscilloscope is a wide-range dual-beam laboratory-type instrument providing accurate voltage and time measurements in the dc to 30 Mc frequency range. Two complete horizontal and vertical deflection systems permit completely independent operation of the two beams. Either of the two time-base plug-in units can control the sweep of either or both of the beams. The two vertical channels utilize separate plug-in preamplifier units, allowing you to select the bandpass, risetime, type of input and sensitivity required for your application.

Special circuits incorporated in the system provide selection of an accurate, continuously-variable delay in the presentation of one of the sweeps. The sweep may be delayed from .05 microseconds to 50 seconds after application of a triggering pulse. This feature permits you to expand a selected portion of the delayed sweep, thereby providing precise time measurements and detailed observation of the signal. Both the delayed and the undelayed sweeps are presented on the oscilloscope screen.

VERTICAL DEFLECTION SYSTEM

Characteristics for both vertical channels of the oscilloscope are identical. The actual specifications depend primarily on the vertical plug-in units used with the Type 555. See Table 1-1 for the vertical characteristics of the system when using various plug-in units.

TABLE 1-1

Vertical Characteristics with Specific Plug-In Units*

PLUG-IN TYPE	CALIBRATED DEFLECTION FACTOR	PASSBAND	RISETIME	INPUT CAPACITANCE
TYPE B Wide-Band High-Gain	5 mv/cm to 0.05 v/cm	2 cps to 12 mc	30 nsec	47 pf
	0.05 v/cm to 20 v/cm	dc to 20 mc	18 nsec	
TYPE CA Dual-Trace DC	0.05 v/cm to 20 v/cm	dc to 24 mc	15 nsec	20 pf
TYPE 1A1 Wide-Band Dual-Trace	0.005 to 0.05 v/cm	dc to 23 mc	16 nsec	15 pf
	0.05 to 20 v/cm	dc to 33 mc	11 nsec	
TYPE D High-Gain DC Differential	1 mv/cm to 50 v/cm	dc to 2 mc	0.18 μ sec	47 pf
TYPE E Low-Level AC Differential	50 μ v/cm to 10 mv/cm	0.06 cps to 60 kc	6 μ sec	50 pf
TYPE G Wide-Band DC Differential	0.05 v/cm to 20 v/cm	dc to 20 mc	18 nsec	47 pf
TYPE H Wide-Band High-Gain	0.005 v/cm to 20 v/cm	dc to 15 mc	24 nsec	47 pf
TYPE K Fast-Rise DC	0.05 v/cm to 20 v/cm	dc to 30 mc	12 nsec	20 pf
TYPE L Fast-Rise High-Gain	5 mv/cm to 2 v/cm	3 cps to 24 mc	15 nsec	20 pf
	0.05 v/cm to 20 v/cm	dc to 30 mc	12 nsec	
TYPE M Four Trace DC	0.02 v/cm to 10 v/cm	dc to 20 mc	18 nsec	47 pf

*Data on special-purpose vertical plug-ins given at the end of this section.

HORIZONTAL DEFLECTION SYSTEM

Sweep Rates

From 0.1 microsecond to 5 seconds per centimeter in 24 calibrated steps. An uncalibrated control provides variable control of sweep rates between the calibrated steps, and extends slow sweep range to about 12 seconds per centimeter.

Accuracy of calibrated sweep rates is within 3% (typically 1%) with magnifier off.

Magnifiers

Provide horizontal 5X magnification of the center 2-centimeter portion of the unmagnified crt display when the internal time base generators provide the horizontal deflection.

Extend the fastest sweep rate of either beam to 0.02 microsecond per centimeter. Sweep rates are accurate to within 5% with magnifiers on.

External Horizontal Inputs

Rear-panel connectors permit application of external horizontal signals.

Deflection Factor—Continuously variable from approximately 0.2 volts per centimeter to approximately 20 volts per centimeter.

Passband—Dc to approximately 350 kc (3 db down) at maximum gain.

Input Impedance—Approximately 1 megohm resistance with 47 pf parallel capacitance with the HORIZ. DISPLAY switch set at EXT. ATTEN. X1.

Sweep Modes

Type 21A in Time Base A compartment—Normal, automatic baseline, and single sweep.

Type 22A in Time Base B compartment—Normal, automatic baseline, single sweep, sweeps once for each 'A' delayed trigger, and triggerable once for each 'A' delayed trigger.

Automatic baseline mode operates only on signals with repetition rates above 20 cps. Below 20 cps one of the other sweep modes must be used.

Triggering Signal Sources

Upper beam or lower beam vertical amplifiers, external signals or power line signals; upper beam or lower beam plug-in units when using multi-trace vertical plug-in units with single-channel trigger pickoff.

Trigger Slope and Coupling

Positive (+) or negative (—) slope, ac- or dc-coupled.

Triggering Signal Requirements

(S/N 11000-up)

Internal—Signals producing a minimum of 0.2 centimeter of vertical deflection (+ AC only) up to 1 kc, or 2 centimeters of deflection (\pm AC) up to 30 mc.

External—Signals with minimum of 0.5 volt peak to peak (\pm AC and \pm DC) up to 1 kc, or 0.6 volt (\pm AC only) up to 30 mc.

(The triggering LEVEL control has range of ± 10 volts and the VERNIER control has a range of ± 1 volt, making the overall range ± 10.1 volts. The instrument will trigger on signals larger than ± 10.1 volts, but the LEVEL and VERNIER control will not be completely effective in determining the triggering level.)

(S/N 7000-10999)

Internal—Signals producing a minimum of 0.2 centimeters of vertical deflection, up to 5 mc, or 1 centimeter of deflection up to 30 mc.

External—Signals with minimum of 0.2 volts peak-to-peak up to 10 mc, or 0.5 volts up to 30 mc.

(The instrument will trigger on signals greater than 10 volts, but the LEVEL control is effective over a range of ± 10 volts. The VERNIER control operates over a ± 1 -volt range.)

Delayed Sweep

Sweep Delay—0.1 microsecond to 50 seconds, continuously variable.

Incremental Accuracy—Within 0.2%, between the 1.00 and 10.00 positions of the DELAYED TRIGGER control, on any single setting of the TIME/CM switch.

Overall Accuracy—Within 3% of the indicated value.

Time Jitter—Less than 1 part in 20,000.

CATHODE RAY TUBE (crt)

Type

T5550-2-1 (internal graticule).*

Phosphor

Type P2 normally supplied; types P1, P7 and P11 optional; other types available on special order.

Accelerating Potential

10,000 volts.

Useable Viewing Area

6 by 10 centimeters. The 6-centimeter vertical dimension consists of 4 centimeters for each beam with 2 centimeters common to both beams.

Trace Alignment

Traces are parallel to each other within 0.1 major division per 10 major horizontal divisions, when the traces are centered vertically and there is no input signal.

*Crt type is T5550-2 (external graticule) for instruments with S/N's 7000-8999.

Internal Unblanking

Intensity-type, dc-coupled.

External Intensity Modulation (Z-axis)

Coupling—Input signals ac-coupled to crt control grids through rear-panel connectors.

Input Time Constant—Typically about 10 milliseconds with low external impedance.

Input Amplitude—Typically a 20-volt peak-to-peak signal will produce normal intensity modulation.

Multi Trace Chopped Blanking

Crt circuit permits vertical plug-in units with multi-trace blanking to turn off the display while switching between input channels.

Internal Graticule

Markings—6 vertical and 10 horizontal 1-centimeter (major) divisions; 2-millimeter markings (minor divisions) on the vertical centerline and on the upper beam and lower beam horizontal centerlines 2 centimeters from the top and bottom of the graticule.

Illumination—Variable edge lighting.

AMPLITUDE CALIBRATOR

Output Waveform

Square-wave signal at approximately 1,000 cps.

Output Voltage

0.2 millivolts to 100 volts peak-to-peak in 18 steps.

Accuracy

Peak-to-peak amplitude within 3% of indicated voltage with load impedance above 1 kilohm.

INSTRUMENT POWER

Internal Power Supplies

Electronically regulated circuits for stable operation on power line voltages from 105 volts to 125 volts when wired for 117-volt operation; from 210 volts to 250 volts when wired for 234-volt operation.

Line Voltage

The line voltage for which the instrument is wired is indicated on a metal tag on the rear panel of the power supply unit.

Changes can be made in the internal wiring to permit operation on design-center voltages of 117 or 234 volts, as indicated on the Decoupling Network schematic diagram. Wiring changes for the power transformers, saturable reactor and fans are all shown on the diagram.

Line Fuses (located on the front panel of the power supply unit) are 7 amp slow-blowing for the AC Heaters and 5 amp slow-blowing for the DC Supplies for 117-volt operation; 4 amp slow-blowing for the AC Heaters and 3 amp slow-blowing for the DC Supplies for 234-volt operation.

Line Frequency

50 cps to 60 cps.

Power Consumption

Maximum of about 1050 watts including plug-in power consumption.

OTHER CHARACTERISTICS

Output Signals Available

Calibrator—1 kilocycle (approx.) square wave, at amplitudes from 0.2 millivolts to 100 volts.

Delayed Trigger Pulse—Differentiated positive-going pulses approximately 5 volts in amplitude, occurring at the end of the delay period. Repetition rate of pulse is the same as that of 'A' time base generator.

'A' + Gate—Positive-going signal approximately 25 volts peak-to-peak, with a pulse duration equal to the duration of 'A' sweep and a repetition rate equal to that of the 'A' time base generator.

'B' + Gate—Positive-going signal approximately 25 volts peak-to-peak, with a pulse duration equal to the duration of 'B' sweep and a repetition rate equal to that of the 'B' time base generator.

'A' Sawtooth—Time base 'A' sweep sawtooth waveform, 150 volts in amplitude.

'B' Sawtooth—Time base 'B' sweep sawtooth waveform, 150 volts in amplitude.

Ventilation

Separate forced filtered air systems for the two units. In the event of overheating, the self-resetting thermal relay interrupts instrument power.

Construction

Aluminum-alloy chassis and cabinets. Photo-etched anodized front panels; blue vinyl-finished cabinets and rear panels. Side and bottom panels separately removable.

Dimensions

Indicator Unit—13 inches wide; 20 inches high; 24 inches deep. Weight without vertical plug-in units: 68 pounds.

Power Supply Unit—13 inches wide; 10 inches high; 17½ inches deep. Weight: 45 pounds.

Standard Accessories

- 1—Time base plug-in extension (013-013)
- 4—Attenuator probes, 10X Attenuation (010-127)
- 1—Inter-unit power cable (012-032)
- 2—BNC to binding post adapters (103-033)

- 1—Test lead (012-031)
- 1—Polarized light filter (378-545)*
- 1—3-conductor power cord (161-010)
- 1—3 to 2-wire adapter (103-013)
- 2—Instruction manuals (070-403)

SPECIAL-PURPOSE VERTICAL PLUG-IN UNITS

Type N

The Type N Sampling Unit when used with the Type 555 Oscilloscope permits observation of repetitive signals with fractional nanosecond (10^{-9} second) risetimes. Samples of the input signal are taken, each sample on a different cycle of the signal and slightly farther along the waveform, and the input signal is reconstructed on a relatively long equivalent time base. Characteristics of the Type N include: 0.6 nanosecond risetime, corresponding to a passband of approximately 600 mc; 10 millivolts per centimeter input deflection factor with less than 2 millivolts of system noise; ± 120 -millivolt dynamic range; equivalent sweep rates from 1 nanosecond per centimeter to 10 nanoseconds per centimeter.

Type O

The Type O Plug-In Unit is a dual channel operational amplifier capable of performing the operations of integration, differentiation, function generation, and linear and nonlinear amplification. When used with the Type 555 Oscilloscope the passband of each channel is dc to 25 mc. The two channels can be used in series to perform two operations simultaneously, such as double integration.

Input impedances can be selected from 5 resistance values, from 10 kilohms to 1 megohm, and 6 capacitance values, from 10 picofarads to 1 microfarad. Selection of feedback impedances is from an identical range of values. Output amplitude is ± 50 volts and ± 5 milliamps, and output impedance is approximately 30 ohms.

Type P

The Type P Plug-In Unit generates a fast rise step-function test signal of known waveform, simulating the output of an ideally compensated Type K Unit driven with a Tektronix Type 107 Square-Wave Generator. The Type P permits the standardization of the main-unit vertical amplifier transient response of a Tektronix plug-in type oscilloscope. Pulse repetition rate is 240 step functions per second, with either positive or negative polarity. Step function amplitude is continuously adjustable between 0 and 3 major graticule divisions. Pulse risetime is approximately 4 nanoseconds.

Type Q

The Type Q Plug-In Unit permits any Tektronix plug-in type oscilloscope such as the Type 555 to be operated with strain gages and other transducers. Excitation voltages for the strain gages and transducers are provided by the plug-in unit. The unit provides high gain, low noise, and extremely

low drift. Frequency response of the Type Q Plug-In Unit is dc to 6 kc; risetime is approximately 60 microseconds. Strain sensitivity is calibrated in 10 steps from 10 microstrain to 10,000 microstrain per major graticule division and is continuously variable between steps.

Type R

The Type R Plug-In Unit is a combined power supply and pulse generator which is used to measure the high-frequency characteristics of junction transistors by the pulse-response method. When the Type R is used in the Type 555 Oscilloscope, delay time, risetime, storage time, and falltime may be displayed simultaneously. Calibrated vertical deflection factors range from 0.5 milliamp to 100 milliamps per centimeter. A pushbutton switch connects a front-panel terminal directly to the input of the oscilloscope for observing externally derived waveforms.

Pulse risetime of the Type R Unit is less than 5 nanoseconds and minimum displayed risetime with the Type 555 Oscilloscope is about 12 nanoseconds. Pulse amplitudes range from 50 millivolts to 10 volts in 8 calibrated steps and variable between the steps. Repetition rate is 120 pulses per second.

Type S

The Type S Plug-In Unit is designed to test certain semiconductor diode parameters, such as junction resistance, junction capacitance, and the stored charge at the junction. Performance of a diode in a particular circuit can be predicted by analyzing the recovery and "turn-on" characteristics. Since it is essentially a means for plotting voltage across an element while passing constant current through it, the unit can be used for other applications as well. For example, observing the junction characteristics of transistors, or measuring the resistance, capacitance or inductance of circuit components.

The Type S offers calibrated forward currents in five fixed steps from 1 to 20 milliamps, and reverse currents calibrated in six steps from 0 to 2 milliamps. Diode shunt capacitance is 9 picofarads, and deflection factors are 0.05 and 0.5 volts per centimeter calibrated.

Type Z

The Type Z Plug-In Unit extends the accuracy of oscilloscope voltage measurements. It can be used in three modes of operation: (1) as a conventional preamplifier, (2) as a differential input preamplifier, or (3) as a calibrated differential comparator. With sensitivity of 50 mv/cm and insertion voltage range of ± 100 volts, the effective scale range is ± 2000 cm. Maximum resolution of the Type Z Unit is 0.005%.

As a conventional preamplifier, the Type Z Unit offers a passband of dc to 13 mc with the Type 555 for signals that do not overscan the screen. The deflection factors are 0.05 volts/cm to 25 v/cm in 9 fixed, calibrated steps.

As a differential input preamplifier, the Type Z accepts a common-mode signal level ± 100 volts at minimum deflection factor, and offers a common-mode rejection ratio of 40,000 to 1. Maximum input signal rate of change is +1 volt/7 nsec, or -1 volt/5 nsec.

As a calibrated differential comparator, the Type Z has three comparison voltage ranges: zero to ± 1 volt, zero to ± 10 volts, and zero to ± 100 volts.

*For instruments in serial number range 7000-8999, light filter is green plastic (378-514). Green filter is for use with external graticule; polarized filter is for internal graticule crt.

SECTION 2

OPERATING INSTRUCTIONS

GENERAL INFORMATION

The Type 555 Oscilloscope is a versatile instrument which is adaptable to a great number of applications. To make full use of the potentialities of the instrument, you should become familiar with the function and operation of each of the various controls. This section of the manual provides the basic information required for operation, including the functions of the controls, the use of input cables and probes, triggering of the sweep, and operation of the delayed sweep feature.

Horizontal Sweep

The two plug-in time base units produce the horizontal deflection (sweeping) of the two cathode-ray tube beams. Either beam can be deflected by either time base unit, or both beams can be swept simultaneously by the same unit. The Upper Beam and Lower Beam HORIZ. DISPLAY switches are used to select the time base units to drive the separate beams.

In most applications, the SWEEP FUNCTION switches are used in the AUTO BASELINE or NORMAL positions. These two positions provide normal triggered operation of the time base units. In addition, the AUTO BASELINE provides an automatic sweep of the trace when no signal is applied to the triggering circuit. Other positions of the SWEEP FUNCTION switch permit use of the single sweep and delayed sweep modes of operation.

The sweep rates of the two beams are determined by the settings of the appropriate TIME/CM and HORIZ. DISPLAY switches. In turn, the sweep rate determines the duration of the trigger holdoff period. The two time-base units have identical sweep characteristics. There are 24 calibrated sweep rates ranging from .1 μ seconds to 5 seconds per centimeter. Uncalibrated VARIABLE controls permit the sweep rates to be varied continuously between the steps of the TIME/CM switches, and can extend the sweep rate to about 12 seconds per centimeter when the switch is in the 5 SEC position.

Sweep Triggering

The oscilloscope display is formed by the repetitive sweep of the crt beam from left to right across the oscilloscope screen while an input voltage signal produces vertical deflection of the beam. If the sweeps were allowed to occur at random, or at some rate not related to the repetition rate of the input signal, the displayed waveform would be traced out at a different horizontal position each time and the waveshape would either be indistinguishable or would drift across the screen.

In most cases it is desirable for a repetitive waveform to appear stationary on the oscilloscope screen so that the characteristics of the waveform can be examined in detail. To produce a stationary display, the start of each sweep must be time-related to the repetition rate of the input signal. In the Type 555 Oscilloscope, the starting time of the sweep is related to the displayed waveform by using the input sig-

nal or another time-related signal to start (trigger) the sweep. Figure 2-1 shows the time-relationship between the input signal, the triggering signal, and the horizontal sweep voltage for a typical sine-wave display. The triggering signal is superimposed on a holdoff waveform so the crt beam can retrace to the left of the screen and be ready to sweep again before the trigger signal is allowed to start a new sweep.

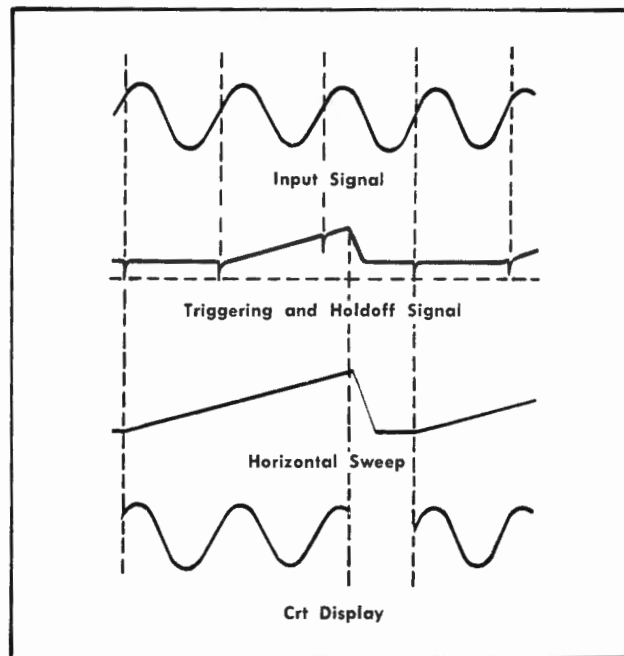


Fig. 2-1. Ladder diagram showing waveform sequence in triggered sweep operation.

INSTALLATION

The two units of the oscilloscope should be placed so that air can circulate freely about them. Ventilation is provided by fans in the separate units that draw air in through filters at the rear of the units. Side panels should be in place for proper operation. Never operate the oscilloscope without the fans operating. If the internal temperature in either unit becomes too high, a thermal cutout will open and disconnect the power until the temperature has returned to normal. If this occurs, check the air filters and the clearance around the units. A constant temperature is important for accurate operation of the instrument. Keep the air filters clean in accordance with the instructions given in the Maintenance section of this manual.

Transformer Conversion

This instrument is wired to operate with the line voltage indicated on the tag adjacent to the power plug on the Power Supply Unit. Line frequency must be between 50 and 60 cycles. The transformer can be converted for operation

on nominal line voltages of 117 volts or 234 volts, by changing connections on the two transformers, the fans and the saturable reactor. Rewire according to the diagrams shown on the Decoupling Network schematic diagram.

Fuse data is given in the electrical Parts List for replacing fuses or converting to another line voltage.

SELECTION OF PLUG-IN UNITS

The Type 555 Oscilloscope is designed to use Tektronix letter-series and 1-series plug-in units as the input stages for the two vertical deflection systems, and Types 21A and 22A Time-Base Units to generate the horizontal sweep voltages.

The use of plug-in units at the vertical inputs permits you to change the vertical characteristics of the oscilloscope to meet a wide range of application requirements. The particular plug-in units to be used must be selected to satisfy the requirements of your applications. In selecting the vertical plug-in units, you must consider the bandpass, risetime, deflection factor and number and type of inputs required.

Plug-in type time-base units are used primarily for ease of servicing and calibration. The plug-in extension accessory supplied with the Type 555 allows the instrument to be operated with either time base unit partially extended from the oscilloscope. For normal operation, the Time Base Units are left in the Type 555, and are held in place by thumb-screws located at the rear of the time-base compartments. The side panels of the oscilloscope must be removed to gain access to the retaining screws (see Fig. 2-2).

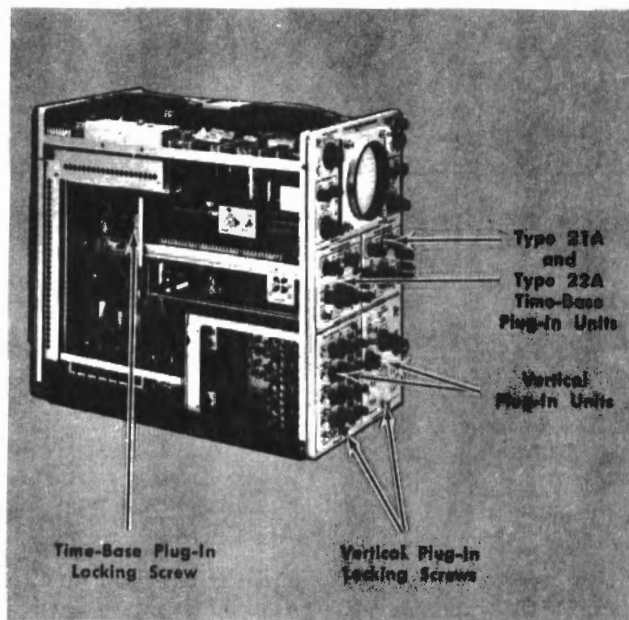


Fig. 2-2. Location of the time-base and vertical plug-in locking screws.

Normally, a Type 21A Time-Base Unit is used in the Time Base A plug-in compartment, and a Type 22A Time-Base Unit in the Time Base B compartment. Either a Type 21A or a Type 22A may be used for Time Base A; however, a Type

22A must be used for Time Base B in order to use the delayed sweep feature of the instrument.

The Type 555 Oscilloscope should not be used without all of the plug-in units installed or connected by extensions. Operating the instrument with a plug-in unit missing will not damage the oscilloscope, but may cause the power supplies to go out of regulation due to insufficient loading. The instrument will not operate correctly unless the power supplies are regulating.

FRONT AND REAR-PANEL CONTROLS

All controls and connectors required for the operation of the Type 555 are located on the front panels of the oscilloscope and its plug-in units and on the rear panel of the oscilloscope (see Fig. 2-3). Some of the controls which have complex functions are treated in greater detail later in this section, in the discussions of the various modes of operation.

FUNCTIONS OF CONTROLS AND CONNECTORS

Indicator Unit

AMPLITUDE CALIBRATOR Switch	Sets the amplitude of the 1 kc (approx.) square-wave signal available at the CAL. OUT connector. Amplitude is adjustable in 18 steps from .2 millivolts to 100 volts, peak-to-peak.
CAL. OUT Connector	Provides 1 kc square-wave output primarily for checking gain of the vertical deflection systems and for adjusting compensation of probes. Amplitude of output signal is controlled by AMPLITUDE CALIBRATOR switch.
SCALE ILLUM. Control	Controls intensity of graticule illumination lamps. Rotate clockwise to increase illumination; counterclockwise to decrease illumination. The lamps edge-light the graticule markings for accurate time and voltage measurements.
DELAYED TRIGGER FROM TIME BASE A (1-10 MULTIPLIER)	Sets time duration between triggering of 'A' sweep and output of Delayed Trigger pulse. (Operates with Time Base A TIME/CM control.) Delayed trigger pulse is delivered to DELAYED TRIG. OUT connector and to Time Base B Trigger circuit for delayed sweep operation.
DELAYED TRIG. OUT Connector	Provides a delayed trigger output pulse from Time Base A for triggering an external device. Delay time is determined by setting of Time Base A TIME/CM switch and DELAYED TRIGGER (1-10 MULTIPLIER) control. (See Fig 2-10).

Upper Beam and Lower Beam

INTENSITY Control	Adjusts the brightness of the display to compensate for changes in brightness caused by changing the sweep or triggering rates. Rotate control clockwise to increase brightness; counterclockwise to decrease brightness.
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	CAUTION: Excessive intensity can permanently damage the phosphors of the crt screen. Use the INTENSITY control to keep the beam brightness turned down below the level that causes a halo to form around the crt spot or trace.		
FOCUS Control	Adjusts focus of crt spot or trace. Adjust for minimum trace width or spot diameter. The internal ASTIG. control for the respective beam also affects the focus of the beam. See the Calibration Procedure for adjustment of the ASTIG. control.	Trigger SOURCE Switch	<p>Selects the source of the triggering signal from one of six sources:</p> <p>UPPER BEAM or LOWER BEAM input signal, from the trigger pickoff in the Vertical Amplifier of the respective beam;</p> <p>UPPER BEAM PLUG-IN or LOWER BEAM PLUG-IN, from the trigger pick-off in the vertical plug-in unit. (These positions apply only to multi-trace plug-in units with trigger pickoff);</p> <p>LINE signal, from the regulated ac circuit (50 to 60 cps);</p> <p>EXT. trigger signal applied through external trigger INPUT connector.</p>
HORIZ. DISPLAY Switch	Selects source of horizontal deflection voltage from either time-base unit or from the external horizontal input. Also selects either an unmagnified (X1) display or 5X magnification (X.2) of the time-base sweep rate and X1 or X10 attenuation of an external horizontal input signal.	Trigger COUPLING Switch	Selects either ac- or dc-coupling of the input triggering signal whether from internal or external source.
HORIZ. POSITION Control	Controls horizontal position of crt spot or trace; positions any portion of a magnified display onto the crt screen. Single knob controls both coarse and fine adjustment of the beam position, using a "backlash" coupling between the two controls.	Trigger SLOPE Switch	Selects either the rising (+) portion or the falling (—) portion of the triggering waveform for triggering the sweep (see Fig. 2-6).
Beam-Position Neons	Indicate the electrical position of the trace or spot, whether on or off the crt screen. Small arrows beside the lamps indicate the direction of the beam from the center of the screen. Both horizontal lamps may light during the sweep of the dot if the sweep rate is slow; both vertical lamps will be unlit if the display is centered vertically.	Trigger LEVEL Control	Selects triggering waveform level that causes trigger circuit to start a sweep. Operates over a ± 10 -volt range.
CRT CATHODE Connector (rear panel)	Permits application of external signal for intensity modulation. Negative-going increases intensity; positive-going decreases intensity. 10-volt signal change produces appreciable intensity modulation. Leave connector grounded except when applying external signal.	Trigger VERNIER Control	Selects triggering level over a ± 1 -volt range for fine adjustment or for use on small triggering signals.
CRT CATHODE Switch	Selects intensity modulation signal from internal multi-trace chopped switching or externally applied signals through CRT CATHODE connector. Leave switch in CRT CATHODE position except when operating in chopped mode.	SWEEP FUNCTION Switch	<p>Selects mode of sweep operation from five basic modes:</p> <p>NORMAL;</p> <p>AUTO BASELINE;</p> <p>SINGLE SWEEP;</p> <p>SWEEPS ONCE FOR EACH 'A' DLY'D TRIG.;</p> <p>TRIGGERABLE ONCE FOR EACH 'A' DLY'D TRIG.</p> <p>(The last two positions are only on the Type 22A.) See text for specific mode of operation.</p>
EXT. HORIZ. INPUT Connector	Permits application of external voltage signal for horizontal deflection of crt beam. Front-panel HORIZ. DISPLAY switch must be in one of the EXT. ATTEN positions.	TIME/CM Switch	Sets sweep rate of the beam (or beams) using that time-base unit for generation of the sweep voltage. Sweep rates range from .1 μ seconds to 5 seconds per centimeter.
EXT. HORIZ. GAIN Control	Controls amount of horizontal deflection produced by externally applied voltage. Horizontal deflection factor is continuously variable from approximately 0.2 to 2 volts/cm with HORIZ. DISPLAY switch EXT. ATTEN. X1; from 2 to 20 volts/cm with switch at EXT ATTEN. X10.	VARIABLE Control	Varies sweep rate continuously between steps of TIME/CM switch, and extends sweep rate to about 12 seconds per centimeter with switch in the 5 SEC position. Sweep rate is not calibrated when using VARIABLE control. Leave control in CALIBRATED position for making time measurements.
Time Base A and Time Base B			
Trigger INPUT Connector	Permits application of triggering signal from an external source that is time-related	UNCALIBRATED Neon	Lights when the VARIABLE Control is not in CALIBRATED position.

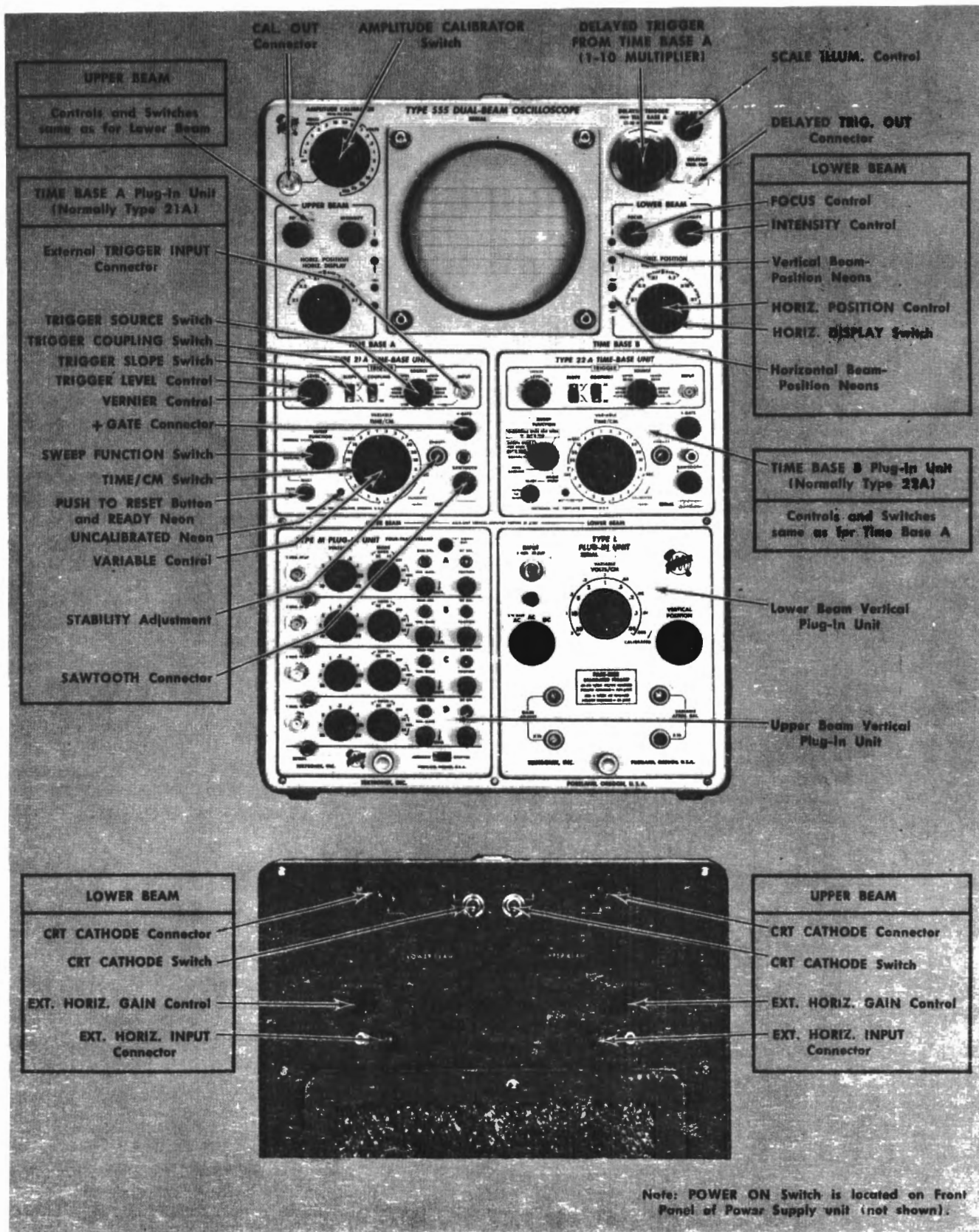


Fig. 2-3. Front- and rear-panel controls and connectors.

PUSH TO RESET Button	Resets Single Sweep Lockout circuit to a triggerable condition.
READY Neon	Lights when Single Sweep Lockout circuit is in triggerable condition; light goes out when sweep is held off after single sweep of the crt.
STABILITY Adjustment	Sets input level of Sweep Gate circuit for stable triggering.
SAWTOOTH Connector	Provides output of horizontal deflection voltage waveform, 150 volts peak-to-peak, capable of driving or triggering external devices. Time Base B sawtooth waveform includes delay time when operating in delayed mode.
+GATE Connector	Provides output of sweep gating waveform, 20 volts peak-to-peak. Time Base B +Gate waveform contains delay time when operating in delayed mode.
Power Supply Unit	
POWER ON Switch	Applies line power to low-voltage power transformers. A time-delay relay allows the tube cathodes to warm up before dc power is applied to circuits.
Power Indicator Lamp	Indicates that ac line voltage is applied to the low-voltage circuit.

Output Signals

Several low-impedance signal outputs are available at the front panel of the Type 555 Oscilloscope system. These are: an Amplitude Calibrator square wave; a Delayed Trigger pulse; a +Gate waveform from each time-base unit; and a Sawtooth waveform from each time base. Typical waveforms are illustrated in Fig. 2-4. In addition, some multi-trace vertical plug-in units provide an amplified single-channel signal output for triggering oscilloscopes from only one input signal. In the Type 555, these units apply the single-channel signal to the triggering circuits through internal wiring.

Use of the +Gate and Sawtooth waveforms for triggering or driving external devices is illustrated in Fig. 2-8. In this application, the time-base unit is usually set for a free-running sweep.

Calibrated Graticule

The edge-lighted internal graticule is accurately marked with 10 horizontal and 6 vertical 1-centimeter divisions and 2 millimeter subdivisions marked on the vertical centerline and the two horizontal centerlines. The deflection factors of the crt beams are calibrated to these graticule marks. Thus the marks provide a calibrated scale for making time and voltage measurements.

To protect the bonded plastic faceplate of the internal graticule crt (instrument S/N's 9000-up), always use a scratch shield or plastic light filter in front of the crt. The shield and filter are provided with the instrument. For normal viewing and for photographing the display, use the clear plastic scratch shield. For viewing under bright ambient light conditions, use the light filter to provide better trace-to-screen contrast. When using the light filter, however, be careful not to set the beam intensity so high that it will burn the crt phosphor.

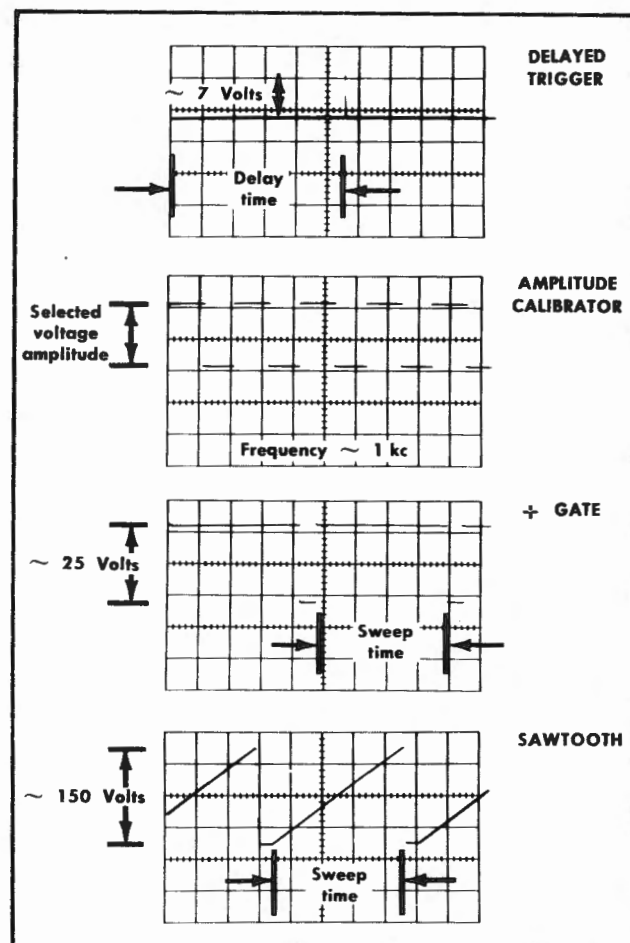


Fig. 2-4. Output waveforms available at the front panel.

For instruments with external gratitudes (S/N's 7000-8999), the color of the graticule illumination may be changed from white to red, or vice versa, by rotating the graticule 180°.

Vertical Controls

The vertical plug-in unit for each beam contains all the front-panel vertical positioning and deflection controls for that beam. Refer to the instruction manuals of the particular plug-in units for operation of the vertical controls.

CONNECTING TO THE SIGNAL SOURCE

Input signals that are to be displayed as vertical deflection on the crt screen are applied to the input connectors on the two vertical plug-in units.

Use of Coaxial Cables

In general, coaxial cables should be used to connect the signal source to the vertical input. The use of coaxial cables nearly eliminates pickup from stray electromagnetic fields, and also eliminates radiation from the connecting cables by grounding the outside conductors. It is sometimes possible to use an unshielded input lead if the signal amplitude is high and if its frequency is low. When an unshielded lead is used,

connect another lead between the oscilloscope chassis and the chassis of the signal source.

In high-frequency work it is usually necessary to terminate signal sources and connecting cables in their characteristic impedances. Underterminated connections result in signal reflections within the cables and cause distortion of the displayed waveforms. The input coaxial cable will often serve to terminate the signal source, and a termination placed at the input of the plug-in unit will provide sufficient termination for signal reflections. However, if the source impedance is considerably different from that of the connecting cable, the source end of the cable may also need to be terminated.

When connecting an input signal, the loading effect of the oscilloscope on the signal source must be considered. The resistance at the input of the vertical plug-in unit is usually 1 megohm which adequately limits low-frequency loading to a negligible value. However, at high frequencies, the input capacitance of the vertical plug-in and the distributed capacitance of the input cable becomes significant. Capacitive loading at high frequencies may be sufficient to adversely affect both the displayed waveform and the operation of the signal source. Attenuator probes can be used to reduce capacitive and resistive loading to very small values.

Use of Probes

In addition to reducing the load on the signal source, an attenuator probe also decreases the amplitude of the displayed waveform by the attenuation factor of the probe. This permits observation of signals beyond the normal amplitude limits of the oscilloscope and plug-in combination. Signal amplitudes, however, must be limited to the maximum allowable value of the probe being used.

Before a probe is used, it must be compensated to operate properly with the plug-in unit. Compensation of the probe is adjusted according to the procedure given in the instruction manual with the vertical plug-in unit and in the instructions accompanying the probe. In general, this adjustment is done by connecting the probe cable to one of the vertical inputs and observing several cycles of the calibrator waveform on the crt screen. The compensating capacitor is then adjusted to provide minimum distortion of the top and leading corner of the square-wave signal (see Fig. 2-5).

TRIGGERING THE SWEEP

For most applications the oscilloscope sweep must be triggered by some signal that is time-related to the input signal being observed on the crt. This section discusses the selection of a suitable triggering signal and the use of the triggering controls.

Internal Triggering Sources

Either time-base unit can be triggered internally from the Upper Beam Vertical Amplifier, the Lower Beam Vertical Amplifier, the Upper Beam plug-in unit, the Lower Beam plug-in unit, or the power line signal. In addition, an external source can be used for triggering with the trigger signal applied to the external trigger INPUT connector on the time-base unit. Selection of the triggering signal is made with the SOURCE switch.

It is usually most convenient to trigger internally from one of the input signals by setting the SOURCE switch to either UPPER BEAM or LOWER BEAM. With the switch in one of these positions, a sample of the vertical signal is picked off from the selected Vertical Amplifier circuit and applied to the Trigger circuit.

If a multi-trace plug-in unit with single-channel trigger pick-off is used, set the SOURCE switch to UPPER BEAM PLUG-IN or LOWER BEAM PLUG-IN to apply the single-channel signal internally to the Trigger circuit. When a multi-trace display is triggered in this manner, each trace is triggered at the same point each time, relative to the channel used for triggering.

NOTE

If a Type 555 with Serial Number 7000 or above is to be used with Type 21 and Type 22 Time-Base Units, the wire between pin 19 on the interconnecting plug and the ceramic strip (inside each time-base unit) should be removed. Otherwise the oscilloscope will not be compatible with multi-trace vertical plug-in units with single-channel pickoff.

If a Type 555 with Serial Number below 7000 is to be used with Type 21A and Type 22A Time-Base Units, the oscilloscope will need to be modified to provide internal connection of the multi-trace single-channel triggering signal. Without the modification, the UPPER BEAM PLUG-IN and LOWER BEAM PLUG-IN positions of the SOURCE switches are disconnected. Order modification kit number 040-328.

Triggering from the power line is sometimes useful when the vertical input signal is time-related to the line frequency. This type of operation is used when the input signal is not satisfactory for triggering. Set the SOURCE switch to LINE for stable triggering on the constant-amplitude line-frequency waveform.

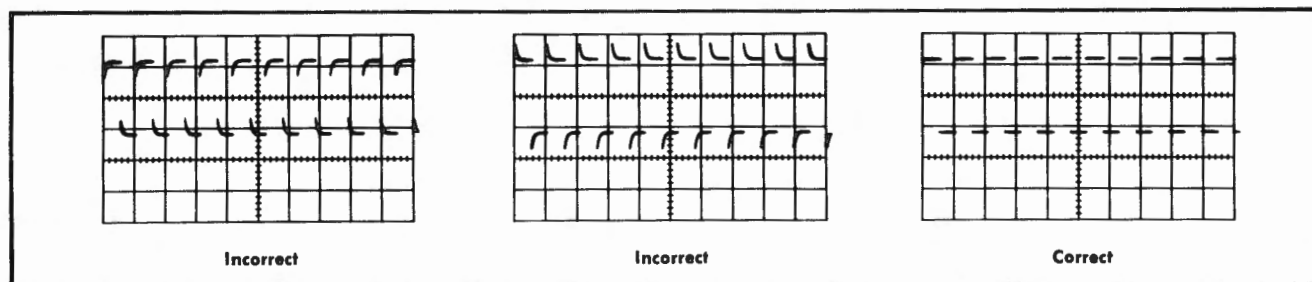


Fig. 2-5. Probe compensation waveforms.

External Triggering Sources

If a triggering signal is required with characteristics other than those of the input signal, it can be applied by means of the external trigger INPUT connector. The signal may be introduced through a jumper lead, a coax cable, or a probe connected to the trigger INPUT connector. Set the SOURCE switch on the time-base unit to EXT.

External triggering is convenient for signal-tracing in a device under test. The triggering signal can be taken from any convenient point in the circuit, then signals can be observed anywhere in the circuit without readjusting the triggering controls. Phase- and time-relationships between the signals can be determined directly from the crt display when the triggers are taken from a single source. This is particularly useful with multi-trace plug-in units.

Triggering from an external source increases the accuracy of time-jitter measurements when the trigger source is more stable than the displayed input signal.

Triggering Controls

The trigger SLOPE switch provides selection of triggering from either the rising (+ slope) or falling (— slope) portion of the triggering waveform (see Fig. 2-6). In many applications it is necessary to trigger on the proper slope to provide the desired display, although some waveforms can be triggered on either slope. Generally, the steepest portion of the waveform will provide the most stable triggering, but final selection of the triggering slope will depend on both the nature of the triggering signal and the type of display desired.

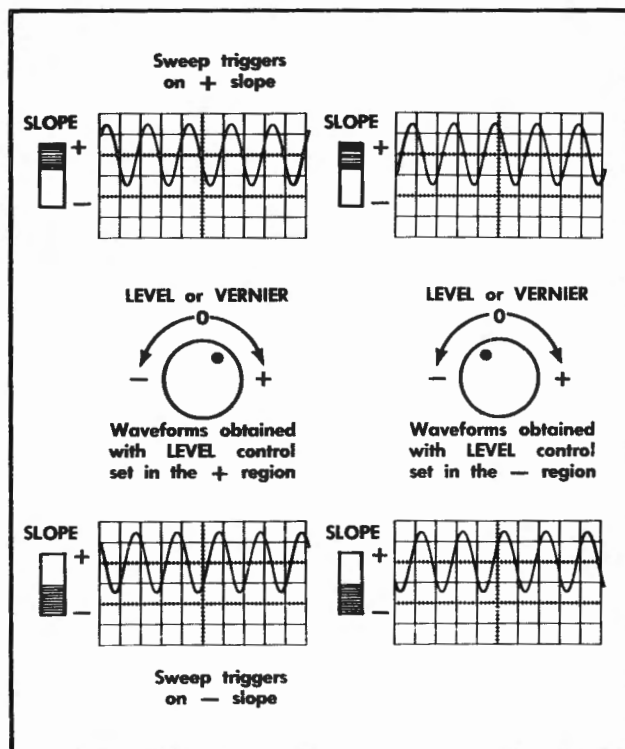


Fig. 2-6. Effects of the trigger SLOPE, LEVEL and VERNIER controls.

The trigger COUPLING switch determines whether the triggering signal is ac or dc-coupled to the Trigger circuit. The AC position of the COUPLING switch is used for most applications, since triggering is then not affected by the vertical position of the waveform on the crt screen. The DC position of the switch should be used if triggering is desired at a particular dc level, or if triggering is done on very low frequency signals.

The trigger LEVEL and VERNIER controls set the level on the triggering waveform where triggering occurs (see Fig. 2-6). These are the last controls to be set when triggering the display. The LEVEL control, which operates over a ± 10 -volt range, has ten times the effect of the VERNIER control.

To trigger the sweep, center the VERNIER control and rotate the LEVEL control until a stable display of the waveform is presented on the crt screen. Fine adjustment of the triggering level can then be made with the VERNIER control. Turning counterclockwise causes triggering at a more negative point on the waveform, and turning clockwise causes triggering at a more positive point. Normally these controls are approximately centered when the display is properly triggered. The VERNIER control is convenient for adjusting the trigger level when small or high-frequency triggering signals are used.

FIRST-TIME OPERATION

The following procedure is suggested for setting the instrument in operation to display the input signals. Dual-beam operation is illustrated.

Connect the two main units of the instrument together with the inter-unit cable and connect the Power Supply Unit to the power line. With time-base and vertical plug-in units installed in the Indicator Unit, set front-panel controls to the following positions:

	Upper Beam
FOCUS	Centered
INTENSITY	Counterclockwise
HORIZ. DISPLAY	TIME BASE A X1

	Lower Beam
FOCUS	Centered
INTENSITY	Counterclockwise
HORIZ. DISPLAY	TIME BASE B X1

Time Base A and Time Base B

TIME/CM	Set to display 2 or 3 cycles of the input waveform; if unknown, start with .5 mSEC.
VARIABLE	CALIBRATED
SWEEP FUNCTION	AUTO BASELINE
LEVEL	Clockwise
SLOPE	Set to + for positive slope; — for negative slope, as desired.
COUPLING	AC for most signals; DC for low-frequency triggering.

Time Base A SOURCE	UPPER BEAM
Time Base B SOURCE	LOWER BEAM

Vertical Plug-In Units

Deflection Factor	Set to produce 2 or 3 cm of deflection on crt screen.
Input Coupling	AC for most signals; DC for determining dc levels.

Connect input signals to the vertical input connectors of both beams as described previously. If an external triggering signal is desired, connect it to the external trigger INPUT connector and set the appropriate SOURCE switch to EXT.

Turn on the instrument with the POWER switch on the front panel of the Power Supply Unit and allow a few minutes for the units to warm up. A time-delay relay in the Power Supply Unit delays the operation of the instrument for approximately 45 seconds after the power switch is turned on. This delay allows the tubes sufficient time to heat before the dc operating voltages are applied. If the ac power is interrupted for an instant, the normal 45-second delay will occur before the dc power is restored.

Using the beam-position neons as a guide, position the free-running traces on the crt screen, then adjust the INTENSITY control for a trace of adequate intensity.

Rotate the LEVEL controls to trigger the two displays. If the triggering signal is small or of high frequency, the VERNIER control may be adjusted for the most stable triggering. Position the traces with the HORIZ. POSITION controls so they start at the left edge of the graticule, and adjust the FOCUS controls for the sharpest possible focus.

Use of 5X Magnification

The HORIZ. DISPLAY switch of either beam provides selection of five times magnification of the signal displayed on that beam, using either time-base generator to drive the sweep. To magnify the display, move the HORIZ. DISPLAY switch from the X1 position to the X.2 position. The center 2 cm of the display with the switch on the X1 position is then expanded to cover the entire 10 cm of the crt screen (see Fig. 2-7). Any 2-cm portion of the original display, now expanded, can be positioned on the crt screen with the appropriate HORIZ. POSITION control.

The sweep rate of the magnified display is five times that indicated by the TIME/CM switch. The true sweep time per centimeter of the magnified sweep is found by multiplying the reading of the TIME/CM switch by 0.2, or by dividing by five.

If sweep magnification greater than 5X is required, use the delayed sweep magnification mode described later in this section.

Use of Horiz. Position Controls

The two beams have independent horizontal positioning. The Upper Beam HORIZ. POSITION control positions the Upper Beam display; the Lower Beam HORIZ. POSITION

control positions the Lower Beam display. Clockwise rotation of either control causes the trace of the particular beam to move to the right on the crt screen, and counterclockwise rotation moves the trace to the left. When the HORIZ. DISPLAY switch is set for 5X magnification (X.2), the HORIZ. POSITION control provides sufficient range to view any portion of the expanded display.

Each HORIZ. POSITION front-panel knob operates both coarse and fine adjustment of the positioning by means of a backlash coupling between the controls inside the unit. To position the trace horizontally, turn the HORIZ. POSITION control slightly past where you want it, then move it back to the desired final position. The fine adjustment control only operates in the backlash of the coarse adjustment control. For example, to move the trace to the right, turn the HORIZ. POSITION control clockwise for the coarse adjustment until the trace position is about 2 mm past the desired location, then turn the control slightly counterclockwise for fine adjustment of the trace position.

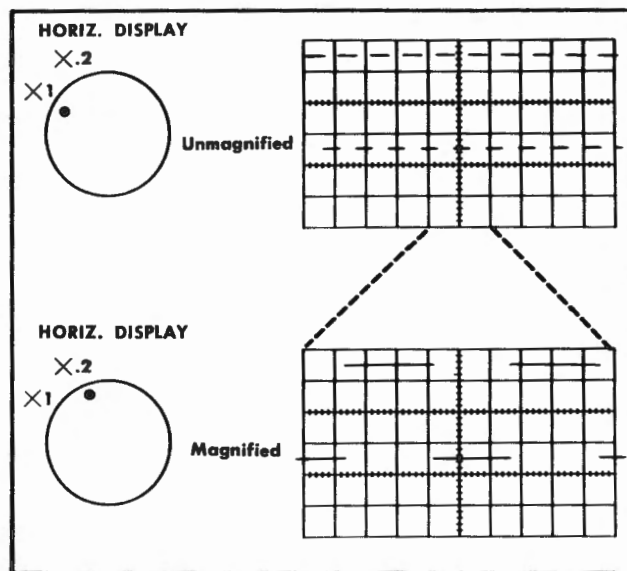


Fig. 2-7. Operation of the 5X sweep magnification.

OPERATING MODES

The Type 555 Oscilloscope provides many modes of sweep operation, making the instrument adaptable to a variety of applications. The normal triggered mode, in which the sweep is started by a signal that is time-related to the displayed input signal, is the most common sweep mode. Operation of both time-base units is the same except for the Delayed Sweep modes.

Triggered Sweep

Set the SWEEP FUNCTION switch to either NORMAL or AUTO BASELINE for normal triggered operation. Trigger the display with the LEVEL and VERNIER controls as described previously. (AUTO BASELINE in the Type 21A and Type 22A is a sweep mode with automatic baseline, rather than the low-frequency automatic triggering mode found in many Tektronix oscilloscopes.) For triggering rates above 20 cps,

triggering is the same in either NORMAL or AUTO BASELINE. In addition, AUTO BASELINE provides a free-running baseline trace when no triggers are applied. For triggering rates below 20 cps, use NORMAL position of the SWEEP FUNCTION switch, since AUTO BASELINE will produce an intermittent free-running baseline in this frequency range.

With the SWEEP FUNCTION switch at NORMAL, the sweep is held off until a trigger of the proper amplitude is received. After the beam has swept and retraced, it waits for the next triggering pulse, then begins when the trigger pulse reaches the selected triggering level.

With the switch set to AUTO BASELINE and the triggering control set for triggered operation, the sweep is free running in the absence of triggers. When a trigger is received, the Time-Base Generator stops free running. Then, if another trigger pulse is received within 1/20th of a second, a normal triggered sweep of the trace will occur (if the sweep is ready to be triggered). However, if no trigger pulse arrives within 1/20th of a second, the auto baseline circuit will again cause the Time-Base Generator to free run until another trigger pulse is received.

Free Run

To free run the sweep, set the SWEEP FUNCTION switch on the time-base plug-in unit to AUTO BASELINE and turn the LEVEL control either fully clockwise or fully counterclockwise. In AUTO BASELINE, with no triggering signal applied, the sweep will free run in nearly any position of the LEVEL control, however random triggering will occur on stray noise signals when the control is set at the zero triggering level, causing intermittent free run operation. Therefore it is recommended that the LEVEL control be set at either end of its range. This will also allow a signal display to free run when the trigger amplitude is less than 10 volts. If you desire to free run the sweep in the presence of a large input signal, set the SOURCE switch to some position receiving no input signals (e.g. EXT.).

A free-running sweep is convenient for locating and positioning the crt beam while no input signal is applied. It also can be used to establish a reference voltage level for making dc measurements.

With a free-running sweep, one of the time-base generators can initiate the input signal by using the +Gate or Sawtooth output waveform to trigger or drive a device under test. The response waveform will then be synchronized with the sweep repetition rate of the time-base generator and will present a stable waveform on the crt. Set the TIME/CM switch and VARIABLE control to produce the desired repetition rate. (This may be observed by monitoring the output waveform with the other time-base unit.)

To display one cycle of the response waveform, drive the crt beam with the time-base unit that is generating the output +Gate or Sawtooth waveform. Fig. 2-8 illustrates this mode of operation with Time Base B and the Lower Beam. To display more than one cycle or a portion of the waveform, set the HORIZ. DISPLAY switch to the second time-base unit for driving the crt beam. Set the controls of the second time-base unit for triggered operation.

To display both the output waveform and the response from the external device, apply the output signal to one vertical INPUT and the response signal to the other INPUT.

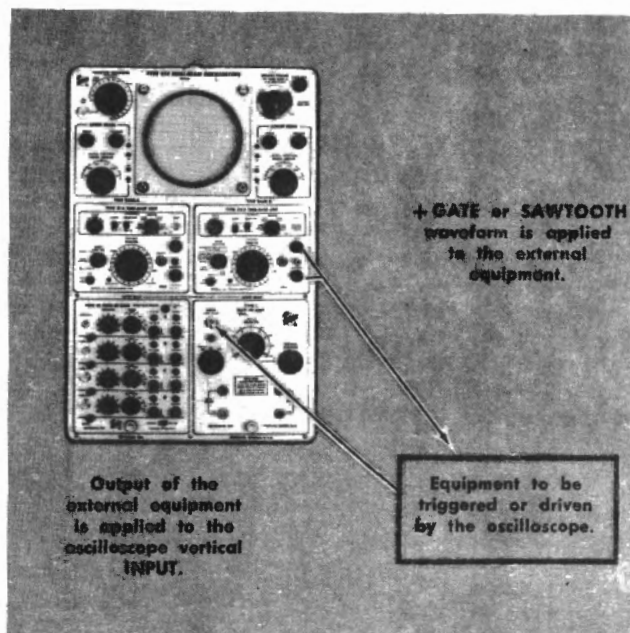


Fig. 2-8. Using the +GATE or SAWTOOTH waveform to trigger or drive external equipment. Sweep is usually free running.

The two beams will then display the waveforms simultaneously. Similarly, two or more response signals from the device under test may be displayed together through use of the two beams and multi-trace plug-in units.

Delayed sweep pulse generation is discussed later in this section of the manual.

Single Sweep

Single sweep mode is used primarily for viewing or photographing a portion of an input waveform that is not repetitive or that varies in amplitude or shape.

To display a triggered single sweep of the crt presentation, first set up the triggering controls with the SWEEP FUNCTION switch set to NORMAL or AUTO BASELINE, then move the switch to SINGLE SWEEP. Press the PUSH TO RESET button and release it. If no trigger is received immediately, the READY lamp inside the PUSH TO RESET button will light, indicating the time-base circuit is ready to be triggered. Then, when a trigger arrives, the crt beam will sweep once, the READY lamp will turn off, and the sweep will be held off until the PUSH TO RESET button is again pressed and released.

Single sweeps will not occur without a triggering signal except by turning the LEVEL control through the normal triggering level. To produce single sweeps without an input signal, the SOURCE switch may be set to LINE position and the LEVEL control adjusted for line triggering. Then the single sweep circuit is armed as the PUSH TO RESET button is pressed and a sweep of the trace occurs as the button is released.

In addition to its usual function in single-sweep mode, the PUSH TO RESET button may also be used to cut off the sweep when the instrument is operating normally in one of the trig-

gered or free-run modes. Whenever the button is pressed and held in, the sweep cannot be triggered and will not free run. Normal operation is restored when the button is released.

Delayed Sweep

The Delayed Trigger pulse which occurs during each sweep of 'A' Time-Base Generator is applied to the 'B' Time-Base Generator as well as to the DELAYED TRIG. OUT connector. This Delayed Trigger from Time Base A can be used to hold off the triggering or sweep of Time Base B for a certain selected period after the Time Base A sweep has started. The delay time is continuously variable from .05 μ sec to 50 seconds. When the Time Base B SWEEP FUNCTION switch is in the SWEEPS ONCE FOR EACH 'A' DLY'D TRIG position, the Time Base B sweep occurs immediately at the end of the delay period. When the SWEEP FUNCTION switch is in

the TRIGGERABLE ONCE FOR EACH 'A' DLY'D TRIG position, the Time Base B sweep is triggerable at the end of the delay period, and will sweep as soon as a pulse is received from the Time Base B Trigger circuit. These two modes are illustrated in Fig. 2-9.

Operation of the delayed trigger and delayed sweep magnification are described in the following paragraphs. Use of the delayed sweep for making time measurements is given in the Applications section of this manual.

a. Delayed Trigger

To use the Delayed Trigger pulses for triggering an external device connect a cable from the DELAYED TRIG. OUT connector to the device under test and connect the response signal to the INPUT of either vertical plug-in unit. Set the

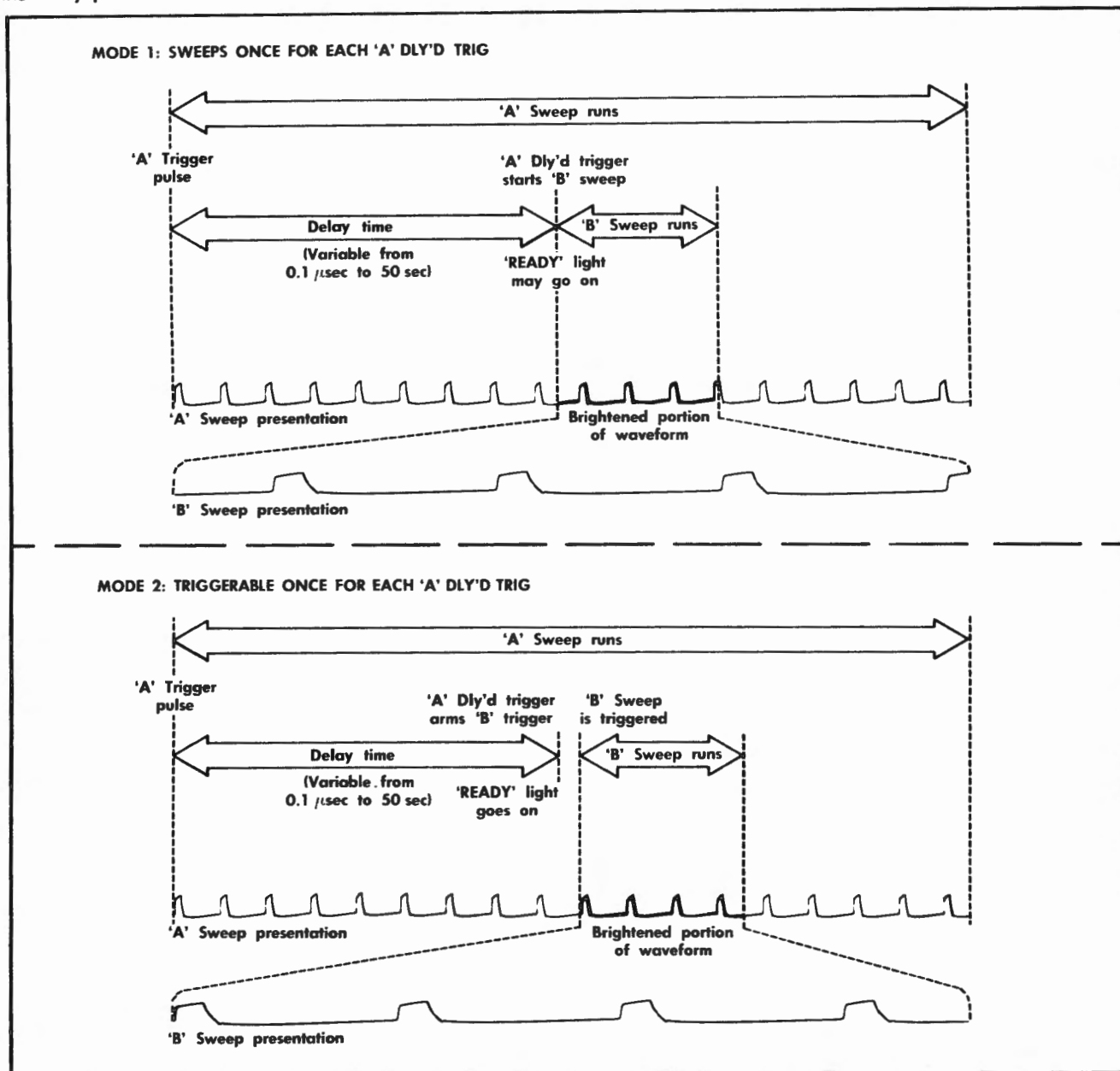


Fig. 2-9. Comparison of the two delayed-sweep modes. In each case the 'A' presentation represents the input to both vertical systems. The intensified portion of the 'A' presentation shows the part of the input waveform that is displayed in the 'B' presentation.

HORIZ. DISPLAY switch for that beam to Time Base A X1 to display one cycle of the waveform. Selection of the triggering source and sweep mode will depend on the application.

The Delayed Trigger pulse is available at the DELAYED TRIG. OUT connector at any time the Time Base A sweep generator is running. One output pulse will occur for each sweep, at a time determined by the setting of the DELAYED TRIGGER 1-10 MULTIPLIER dial. Set the Time Base A TIME/CM switch and the 1-10 MULTIPLIER dial so their product equals the desired delay time, from 0.1 μ sec to 135 seconds (see Fig. 2-10).

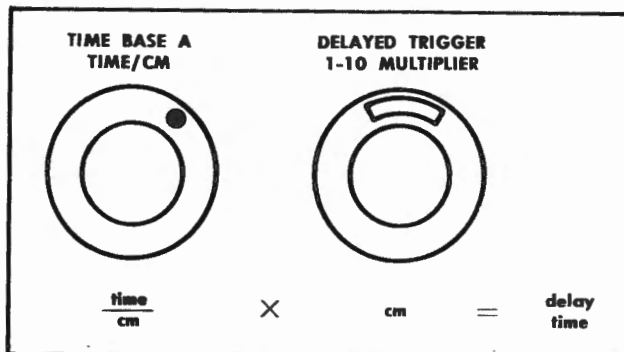


Fig. 2-10. Delay time is calculated by multiplying the Time Base A sweep rate by the 1-10 MULTIPLIER reading.

Since the 1-10 MULTIPLIER control determines the time of occurrence of the Delayed Pulse, it also positions the waveform on the crt screen when sweeping with Time Base A. Each whole number on the dial represents 1 cm of displacement from the left edge of the screen.

Time Base A can be either triggered or free run. If it is operated in free run mode, the repetition rate of the Delayed Trigger pulses will be the same as the repetition rate of the 'A' Time-Base Generator circuit at that particular setting of the TIME/CM switch. (This rate can be varied from about 8 μ sec to 50 seconds with the TIME/CM switch.)

If Time Base A is operated in a triggered mode, an output Delayed Trigger pulse will only occur after Time Base A has been triggered and has swept for the duration of the delay time period. Time Base A must complete its sweep and retrace before it is again triggerable. Thus the repetition rate of the Delayed Pulse output when Time Base A is triggered will depend on both the frequency of the triggering signal and the repetition rate of the Time-Base Generator circuit.

Time Base B can be used for displaying more than one cycle of the signal or for viewing an expanded portion of the waveform when Time Base A is set for a low repetition rate. However, the display produced by Time Base B will have to be triggered and will not be positionable with the DELAYED TRIGGER 1-10 MULTIPLIER unless the triggering source is derived from Time Base A. (Trigger Time Base B externally from Time Base A +GATE if this positioning is desired.)

b. Delayed Sweep Magnification

Because triggering circuits are designed to operate on large changes in the input signal, any crt display that is triggered directly from the input signal can only display the por-

tion of the signal that follows the triggering point. Therefore with normal triggering it is not possible to expand and examine any section of the waveform that does not occur immediately after a triggering point. The delayed sweep mode provides a means of delaying the start of each sweep by a selected amount following the triggering point, so that any portion of the waveform can be expanded. Thus by using the variable Delayed Trigger from Time Base A to trigger Time Base B, any portion of a waveform displayed by Time Base A can be examined in detail with Time Base B. Both the magnified and the unmagnified waveforms can then be displayed together on the crt screen. The maximum sweep speed of the beam driven by Time Base B is not actually increased, and the apparent magnification is merely the result of delaying the Time Base B sweep. Delayed triggering provides up to 10,000X apparent sweep magnification of the Time Base A display in this manner.

Either crt beam can be operated in the delayed mode by sweeping it with Time Base B, but usually the Upper Beam is used to display the unmagnified waveform (Time Base A) and the Lower Beam is used for the magnified sweep (Time Base B). In the following discussion it is assumed that the crt beams are operated in this manner.

To magnify a portion of the Upper Beam display:

1. Connect the same signal to both vertical INPUT connectors.
2. Set the Time Base B TIME/CM switch for a sweep rate somewhat faster than that of Time Base A.
3. Set the DELAYED TRIGGER 1-10 MULTIPLIER between 0.50 and 9.50.
4. Trigger the Upper Beam display with Time Base A in the usual manner.
5. Set the Time Base B SWEEP FUNCTION switch to SWEEPS ONCE FOR EACH 'A' DLY'D TRIG.

Position the Lower Beam display on the crt and adjust the INTENSITY and FOCUS controls of both beams for sharp displays of adequate intensity. (Time Base B triggering controls have no effect on the display.) The Upper Beam trace should have a brightened portion indicating the section that is magnified by the Lower Beam (see Fig. 2-11). Turn the 1-10 MULTIPLIER dial and note that the brightened portion moves smoothly along the Upper Beam display. Thus any portion of the Upper Beam display (except the extreme ends) can be magnified on the Lower Beam by adjusting the triggering of Time Base B with the 1-10 MULTIPLIER. The dial readings indicate the number of major graticule divisions between the beginning of the Upper Beam display and the intensified portion of the trace.

The degree of sweep magnification presented in this manner is equal to the ratio of the Upper Beam sweep rate to the Lower Beam sweep rate. For example, if Time Base A is set for 1 mSEC/cm and Time Base B is set for 10 μ SEC/cm, the magnification is 100 times.

If some input other than the Upper Beam signal is displayed by the Lower Beam, the intensified portion will still indicate the time-relationship between the two sweeps, but the Lower Beam presentation will not be a magnified view of the Upper Beam display.

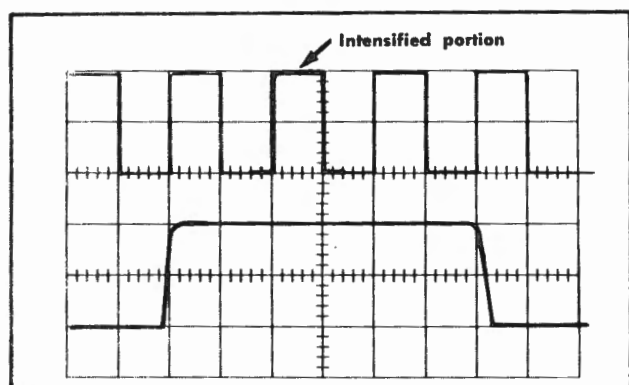


Fig. 2-11. The intensified portion of the upper beam display is expanded and displayed by the lower beam.

c. Triggerable Magnification

When using a high magnification ratio in the delayed mode, time-jitter can sometimes be a problem. Part of the jitter is due to jitter in the signal, and part is due to the delay system. The TRIGGERABLE ONCE FOR EACH 'A' DLY'D TRIG mode allows the Time Base B sweep to be triggered by any small triggering event following the delay time, to eliminate time-jitter.

Set up the delayed sweep presentation in the manner previously described, then set the Time Base B SWEEP FUNCTION switch to TRIGGERABLE ONCE FOR EACH 'A' DLY'D TRIG. Set the Time Base B triggering controls to trigger on the input signal. Then turn the DELAYED TRIGGER 1-10 MULTIPLIER dial and notice that the magnified sweep can be triggered at any small triggering point occurring after the delay interval. The brightened portion of the Upper Beam display will jump from one triggering point to the next as the 1-10 MULTIPLIER dial is turned.

If no triggering signal is applied to Time Base B at the completion of the delay period, the Lower Beam sweep will be held off until a triggering pulse is received. The Time Base B READY lamp will light to indicate that the sweep is ready to be triggered. Then, when the trigger signal appears, the Time-Base Generator will sweep and the READY lamp will turn off. Thus the time between the start of the Time Base A sweep and the start of the Time Base B sweep will depend on the occurrence of the Time Base B triggering signal as well as on the settings of the delay-time controls.

If separate triggering signals are applied, the Time Base B sweep might occur at any time following the delay time period. Therefore the brightened portion of the Upper Beam display may appear any place past the delay time position, or might not appear at all.

d. Delayed + Gate and Sawtooth

To use a delayed + Gate or delayed Sawtooth waveform for pulsing or driving an external device, set up the instrument for delayed sweep operation, then apply the Time Base B + Gate or Sawtooth to the device. Set Time Base A for free-run operation and set the Time Base B SWEEP FUNCTION switch to SWEEPS ONCE FOR EACH 'A' DLY'D TRIG. This will produce a single Time Base B output waveform for each sweep of the 'A' Time-Base Generator. A very narrow pulse can be obtained with Time Base B set for a

sweep rate much faster than that of Time Base A (25 volts amplitude from +Gate; 150 volts from Sawtooth).

Monitor the Time Base B output waveform with another oscilloscope to set up the repetition rate and duty factor. The repetition rate of the output pulse is determined by the setting of the Time Base A TIME/CM switch and VARIABLE control; the duty factor is determined by the setting of the Time Base B TIME/CM switch and VARIABLE control.

e. Time Measurements

Uses of the delayed mode for making accurate time measurements are given in the Applications section of this manual.

External Horizontal Deflection

To deflect one of the crt beams horizontally with an externally-derived voltage signal, apply the external signal through the rear-panel EXT HORIZ. INPUT connector and set the corresponding front-panel HORIZ. DISPLAY switch to one of the EXT. ATTEN positions. The EXT. HORIZ. GAIN control varies the deflection factor from about 0.2 to 2 volts/cm with the HORIZ. DISPLAY switch at the EXT. ATTEN X1 position, and from about 2 to 20 volts/cm with the switch at EXT. ATTEN X10.

Horizontal deflection with an external voltage signal provides low-frequency X-Y operation of the oscilloscope for comparing one function to another, or for making phase comparisons. The upper-limit of the horizontal passband is about 350 kc, therefore X-Y operation must be limited to signals below this frequency.

Time relationship of the X-Y display may be provided through intensity modulation with 10- or 20-volt timing pulses.

Intensity Modulation

The two beams have separate CRT CATHODE input connectors on the rear panel for application of intensity modulation signals.

To modulate one of the crt beams, unground the CRT CATHODE connector, check that the CHOPPED BLANKING—CRT CATHODE switch is in the CRT CATHODE position and apply a 10- to 50-volt signal to the connector. Positive-going voltage signals decrease the beam intensity and negative-going voltages increase the intensity from the level set by the front-panel INTENSITY control.

Intensity modulation can be used to relate other voltage information to the displayed signal without changing the shape of the waveform. Intensity time markers can be added to make time measurements more precise than those obtainable from the graticule marks. Identical signals applied to the two beams can be used to horizontally reference the two beams on the crt screen or to correlate them in time.

Be sure to ground the CRT CATHODE connector when it is not in use.

Multi-Trace Operation

The Type 555 provides a multi-trace sync pulse from each of its time-base units for channel switching in multi-trace vertical plug-in units. The use of multi-trace units provides

simultaneous viewing of several input signals. All of the traces resulting from one vertical input unit will be displayed on one beam and at the same sweep rate.

For plug-in units with single-channel trigger pickoff, the trigger signal is applied internally to the time-base unit when the trigger SOURCE switch is set to UPPER BEAM PLUG-IN or LOWER BEAM PLUG-IN, depending on the position of that multi-trace unit. This permits triggering on only one input signal, thus showing the time-relationships of the displayed waveforms. (Be sure to read the compatibility NOTE in the Triggering section for use of older instruments.)

For multi-trace units without a single-channel trigger output, each trace will be triggered on the waveform from that channel. If the time-relationships of the signals are of interest, an external trigger signal can be used, or the triggers

can be derived from a time-related single input applied to the other beam.

Provision is included in the Type 555 for blanking the switching transients when operating a multi-trace unit in the Chopped mode. During each sweep in the Chopped mode, a sequence of rapid switching occurs from one channel to the next, so that the signal in one channel is displayed for an instant, then the signal in the next channel. Set the CHOPPED BLANKING—CRT CATHODE switch on the rear panel of the Type 555 to CHOPPED BLANKING. This will blank the crt beam while the multi-trace unit is switching from one channel to another. Single-channel triggering is usually desirable for Chopped mode operation. Be sure to return the CHOPPED BLANKING—CRT CATHODE switch to CRT CATHODE for normal operation.

NOTES

SECTION 3

APPLICATIONS

GENERAL INFORMATION

The displayed waveform on the oscilloscope crt screen is normally a plot of voltage per unit time. Voltage is displayed in the vertical direction and time is represented as horizontal deflection. The Type 555 Oscilloscope can be used for making accurate measurements of both voltage and time for one or more input signals by means of the calibrated deflection factors of the two deflection systems. Comparison measurements can also be made of phase and time-relationships between input signals.

VOLTAGE MEASUREMENTS

Vertical deflection of the crt trace is directly proportional to the voltage at the INPUT connector of the vertical plug-in unit at the time of measurement. The amount of displacement for any given voltage can be selected with the input attenuator (Volts/Cm) switch on the plug-in unit. To provide sufficient deflection for best resolution, set the vertical deflection factor so the display spans a large portion of the graticule. Keep the VARIABLE control in the CALIBRATED position.

In general, all voltage measurements are made in the same way, though the techniques may vary for different types of input signals. Voltage-difference measurements (including peak-to-peak) can be made of the ac components of any displayed waveform, and instantaneous measurements can be made from any point on the display to some established reference level. The instruction manuals accompanying most vertical plug-in units describe the voltage measurements possible with the particular units. The basic methods of measurement will also be given briefly here.

When measuring between points on any crt display, be sure to measure consistently from either the top or the bottom of the trace. This will avoid including the width of the trace in the measurements.

Voltage-Difference Measurements

The ac component of any waveform may be measured in terms of the peak-to-peak value or in terms of a voltage-difference between any two points on the display. In many cases either ac- or dc-coupling can be used at the vertical input. In certain applications, however, it may be necessary to use ac-coupling to prevent the dc component of the signal from deflecting the trace off the screen. For very low frequency input signals, dc-coupling must be used for accurate measurements.

Always check the gain of the vertical plug-in unit before making voltage measurements. Set the input attenuator to .05 volts/cm and check for 2 cm of deflection with a .1 volt calibrator signal.

To make a voltage-difference measurement from peak-to-peak or between two points on the display, use the following procedure:

1. With the aid of the graticule scale, measure the vertical deflection in centimeters between the two points on the display. Be sure the VARIABLE control is in the CALIBRATED position.

2. Multiply the divisions of vertical deflection by the numerical setting of the input attenuator and by the attenuation factor of any external attenuators or attenuator probe. This product is the voltage difference between the two points. For a peak-to-peak measurement, this is the ac signal amplitude.

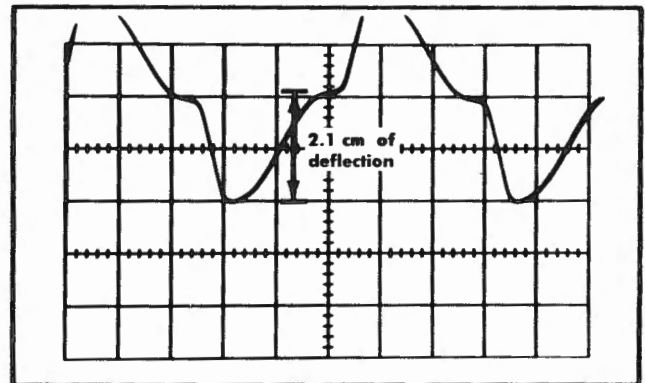


Fig. 3-1. Voltage-difference measurement between two points on the display. Vertical deflection \times Deflection factor \times Attenuation factor = Voltage.

Example: $2.1 \text{ cm} \times 1 \text{ volt/cm} \times 10 = 21 \text{ volts}$.

As an example, Fig. 3-1 shows 2.1 cm of deflection between two points on the display. If the input attenuator is set at 1 volt/cm, multiply 2.1 cm by 1 volt/cm to obtain a product of 2.1 volts, the voltage at the INPUT connector. Assuming the signal is applied through a 10X probe, with no other external attenuator, multiply the 2.1 volts by 10 to obtain 21 volts as the voltage at the source.

For sinusoidal waveforms, the peak-to-peak measurement can be converted to peak, rms, or average values through the use of standard conversion factors.

Instantaneous Voltage Measurements

To measure the instantaneous (dc) voltage between the level of the input signal and some reference voltage such as chassis ground, use the same general procedure as described for voltage-difference measurements. Before connecting the input signal, establish a dc reference level on the crt. To do this, first set the time-base unit for a free-running trace, and set the vertical input coupling to DC. Connect the desired dc reference voltage to the vertical input and position the trace at one of the horizontal graticule lines. The graticule line should be selected on the basis of polarity and amplitude of the signal to be applied. If a probe is to be used to introduce the signal, it should also be used to set up the reference level. From this time on, make no further adjustments with the Vertical Position control. Disconnect the reference voltage.

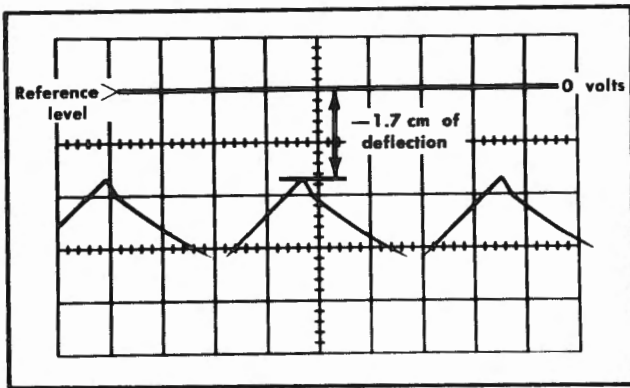


Fig. 3-2. Instantaneous voltage measurement between displayed signal and reference level.

Example: $-1.7 \text{ cm} \times 2 \text{ volts/cm} \times 10 = -34 \text{ volts}$.

Apply the signal and measure the voltage between the established reference level and the selected point of the trace. Fig. 3-2 shows an example of an instantaneous voltage measurement. In the example, the instantaneous voltage is -34 volts, being measured in a negative direction from a reference level of zero volts (chassis ground).

This method may also be used to measure the dc component of any waveform by estimating the average voltage level of the ac component and treating this level as an instantaneous voltage. In general, the average dc level can be estimated by drawing an imaginary line through the ac component of the signal so that the area on the screen, between the waveform and the line, is equal above and below the line (see Fig. 3-3).

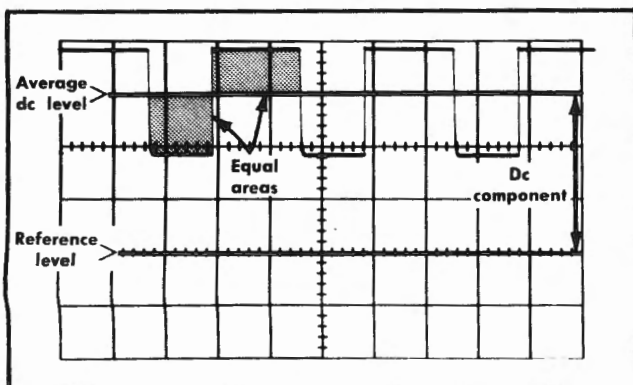


Fig. 3-3. Dc-component measurement of displayed signal. Average dc level separates waveform into regions of equal area.

TIME MEASUREMENTS

The calibrated sweep rates of the horizontal systems cause any horizontal distance on the screen to represent a specific interval of time. Thus the time lapse between any two events displayed by either beam on the oscilloscope screen can be measured directly from the crt screen. The sweep rate most convenient for measuring the input signal can be selected with the TIME/CM switch on the time-base unit.

Set the sweep rate so that the part of the waveform containing the two points of interest is spread over a large portion of the graticule. The sweep rates must be accurately

calibrated and all measurements must be made with the VARIABLE Time/Cm control in the CALIBRATED position. Either of the sweeps may be magnified 5 times through use of the HORIZ. DISPLAY switches for increased resolution. The sweep rate is then determined by multiplying the TIME/CM setting by 0.2.

In addition, the Time Base A sweep may be magnified from 1 to 10,000 times and measured in the delayed sweep mode. Time measurements with the delayed sweep will be described later in this section.

To make a time measurement between two points on a waveform displayed by a single beam, use the following procedure.

1. Using the graticule scale, measure the horizontal deflection in centimeters between the two points on the display. Be sure the VARIABLE Time/Cm control is in the CALIBRATED position.
2. Multiply the divisions of horizontal deflection by the numerical setting of the TIME/CM switch of the time-base unit that is sweeping the beam. This product is the apparent time between the points.
3. If the HORIZ. DISPLAY switch is set at X.2, multiply the apparent time by 0.2 (or divide by 5) to obtain the actual time interval. If the HORIZ. DISPLAY switch is at X1, the actual time interval is equal to the apparent time.

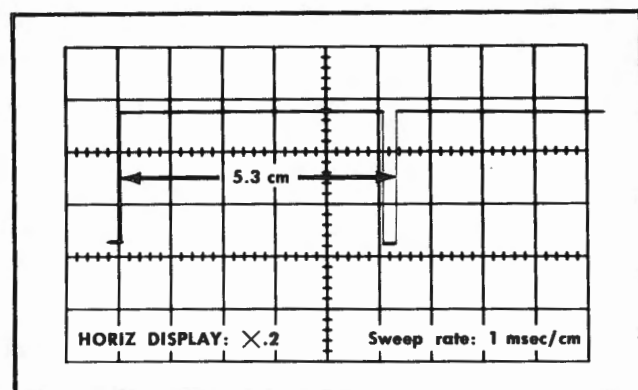


Fig. 3-4. Time measurement from display. Horizontal deflection \times $\frac{1}{\text{Sweep rate} \times \text{magnification}}$ = Time.

Example: $5.3 \text{ cm} \times 1 \text{ msec/cm} \times 0.2 = 1.06 \text{ msec}$.

Fig. 3-4 illustrates an example of time interval measurement from the display. Assuming the TIME/CM switch to be at 1 mSEC and the HORIZ. DISPLAY switch at X.2, the horizontal deflection of 5.3 cm is multiplied by 1 msec/cm to obtain the apparent time of 5.3 msec. The apparent time is then multiplied by 0.2 to give 1.06 msec as the actual time interval. Basic sweep accuracy is 3% at all sweep rates. Accuracy of the time measurement can be improved by checking the accuracy of the particular sweep rate.

If the two events of interest do not closely follow a triggering point on the waveform, it may not be possible to separate the points sufficiently for accurate measurement. If this is the case, use one of the delayed sweep modes to magnify the waveform and measure the time interval as

described above, directly from the delayed sweep. The actual time interval will be the horizontal deflection measurement multiplied by the Time Base B sweep rate.

Dual-Beam Time Measurements

Time-comparison measurements can be made between time-related events displayed by the two beams, if both beams are driven at the same sweep rate. It is generally advisable to use the same time-base unit for driving both beams. This reduces the overall error resulting from sweep rate tolerances.

Since the two beams are positioned independently it is necessary to register the two beams with respect to time before applying the input signals. To do this, connect the calibrator signal to both inputs and set the following controls:

AMPLITUDE CALIBRATOR	.1 VOLTS
TIME/CM	.5 mSEC
Input Attenuator	.05 volts/cm

Trigger the display on the positive slope and position the two waveforms to superimpose them on each other at the center of the graticule. Adjust the two HORIZ. POSITION controls so the rising portion at the start of each trace begins on the vertical line at the left edge of the graticule. Do not change the position of either HORIZ. POSITION control after the beams are thus registered.

Remove the calibrator signal from the two INPUT connectors and connect the two time-related signals to be displayed. Now time-interval measurements can be made between points on the two beams as described above for a single beam.

Accuracy of the time measurements depends on the accuracy of the particular sweep rate used.

Increased Accuracy Time Measurements

The delayed sweep mode may be used to make accurate time measurements on the Time Base A display using the intensified portion of the display as a time marker. In this method, the time interval is read from the 1-10 MULTIPLIER dial. To measure between two points on the Upper Beam display, use the following procedure:

1. Connect the signal source to both of the vertical INPUT connectors.
2. Set up the instrument for delayed sweep operation as described previously, with the Time Base B SWEEP FUNCTION switch in the SWEEPS ONCE FOR EACH 'A' DLY'D TRIG position.
3. Trigger the displays with the Time Base A triggering controls.
4. Adjust the Upper Beam intensity so the brightened portion of the trace is easily visible. Set the Time Base B TIME/CM switch to reduce the brightened portion of the waveform to a small spot or a small portion of the display.
5. With the DELAYED TRIGGER 1-10 MULTIPLIER dial, position the start of the brightened portion to the first point on the Upper Beam display, at the beginning of the time interval to be measured. Then observe the magnified display and position the corresponding point in the Lower Beam display.

play at the vertical centerline. Record the setting of the 1-10 MULTIPLIER dial (e.g. 5.14).

6. Turn the 1-10 MULTIPLIER dial to position the start of the brightened portion at the second point on the display, then center the point on the Lower Beam display. Again record the setting of the 1-10 MULTIPLIER control.

7. Subtract the first reading from the second and multiply by the setting of the Time Base A TIME/CM switch to obtain the time interval between the two points.

A variation of this method is obtained with the signal applied to only one INPUT and the waveform not monitored on the Lower Beam. The beginning of the intensified portion is then positioned with the 1-10 MULTIPLIER at each of the two points and the time interval calculated as described above.

Precision of time measurements made in the delayed sweep mode can be as great as 1 part in 900 if the two points are separated by 9 cm on the crt screen. However, the accuracy of the measurements depends on the linearity of the 1-10 MULTIPLIER dial, as well as on the accuracy of the particular sweep rate used and the accuracy of observations. Linearity of the 1-10 MULTIPLIER dial is within 0.5%. Calibrated sweep accuracy is within 3% at all sweep rates; however, the overall accuracy of measurements can be increased to less than 1% error by checking the sweep rate accuracy on the particular sweep rate used, and by calibrating the Delay Start and Delay Stop adjustments at that sweep rate.

If a number of accurate measurements are to be made at different sweep rates, check the calibration of the sweep rates and the DELAYED TRIGGER 1-10 MULTIPLIER dial at the various sweep rates, and make a table of percentage or fractional correction factors. This will permit rapid calculation of accurate time-interval determinations from the time measurements made with the delay-time controls.

Frequency Measurements

Since the frequency of any repetitive signal is equal to the reciprocal of its period (time required for one cycle), the frequency can be calculated directly from the time interval of one cycle as determined by one of the methods described previously (see Fig. 3-5). Frequency = 1/Period. For example, if the period of a recurrent waveform is measured to be 2.1 μ sec, the frequency equals 1/2.1 μ sec, or 476 mc.

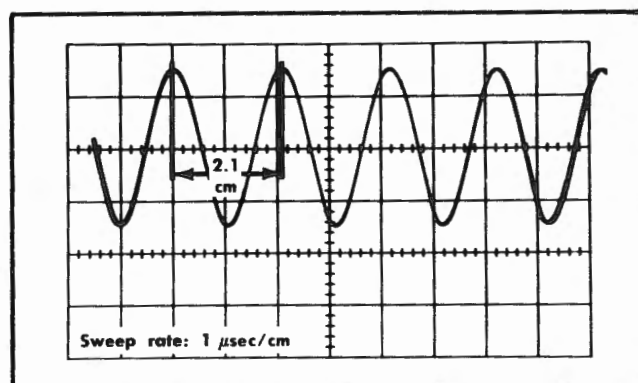


Fig. 3-5. Frequency measurement using the relation: $f = \frac{1}{T}$

Example: $f = \frac{1}{2.1 \mu\text{sec}} = 4.76 \times 10^5 \text{ cps} = 476 \text{ kc.}$

An alternate method of determining frequency from the display that is usually easier and faster to calculate is obtained by dividing the average number of cycles displayed per centimeter of screen by the sweep rate of the display (see Fig. 3-6). Determine the frequency as follows:

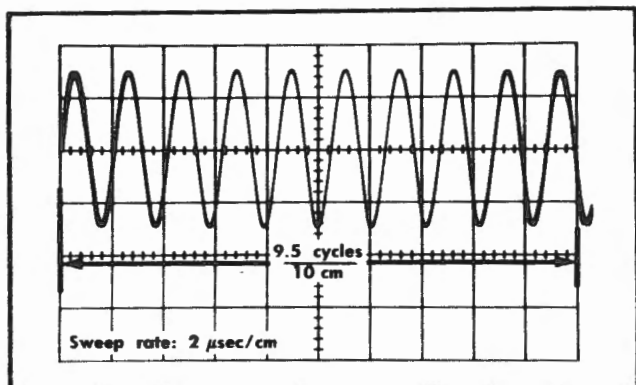


Fig. 3-6. Frequency measurement made from average number of cycles per centimeter of display. (Total cycles ÷ 10 cm) ÷ Sweep rate = Frequency.

Example: (Same signal as Fig. 3-5):

$$\frac{9.5 \text{ cycles}/10 \text{ cm}}{2 \mu\text{sec}/\text{cm}} = \frac{0.95}{2} \text{ cycles}/\mu\text{sec} = 475 \text{ kc.}$$

1. Set the TIME/CM switch to display several cycles of the waveform on the crt screen. Be sure the VARIABLE Time/Cm switch is in the CALIBRATED position.
2. Count the exact number of cycles displayed on the 10 cm of the graticule.
3. Divide the number of cycles by 10 to obtain the average number of cycles per centimeter.
4. Divide the average cycles/cm by the setting of the TIME/CM switch. The result is the frequency of the waveform. (If the HORIZ. DISPLAY switch is at X.2, the apparent frequency will have to be multiplied by 0.2 to obtain the actual frequency.)

As an example, using the same signal as before, with a sweep rate of 2 μsec/cm the number of cycles displayed is exactly 9.5 over the 10 cm of the screen. The 9.5 cycles divided by 10 gives 0.95 cycles/cm. The frequency then is 0.95 cycles/cm divided by 2 μsec/cm, or 0.475 cycles/μsec, which converts to 475 kc.

PHASE MEASUREMENTS

One complete cycle of a sinusoidal waveform, or other trigonometric waveform, is considered to be 360 degrees. Phase comparisons between two or more waveforms of the same frequency can be made with the Type 555 Oscilloscope. Phase angle measurements are commonly used for comparing input and output signals from amplifiers, transformers and filters. Dual-beam or multi-trace operation can be used to display the phases simultaneously on the crt screen. X-Y operation can also be used for determining phase relations of sinewaves up to 300 kc.

To retain exact phase relationships between the signals at their sources, they should be applied to the INPUT connectors through similar lengths of coaxial cable. Triggering of the two-trace displays must be from a single source.

Dual-Beam Phase Measurements

For phase-angle measurements using either dual-beam or multi-trace operation, it is often convenient to first calibrate the sweep in degrees of phase angle per centimeter of display. For instance, if the sweep rate is adjusted with the TIME/CM and VARIABLE Time/Cm controls so that one cycle of the input waveform covers 8 centimeters of the graticule, each centimeter then corresponds to 45 degrees, and the display is calibrated at 45°/cm. Any convenient relationship may be used for this calibration. The use of 45°/cm is suggested because it produces a large display and also calibrates the sweep at 1 quadrant (90°) for every two centimeters.

The relative amplitude of the signals does not affect the phase measurement as long as each signal is centered on the horizontal centerline. However, it is often easier to read the phase difference if the display amplitudes have been adjusted to be the same. Use the following procedure to measure phase angle between two signals in the dual-beam mode:

1. Register the two beams horizontally as described above in Dual-Beam Time Measurements.
2. Connect the reference phase signal to the Upper Beam vertical INPUT, and the second signal to the Lower Beam vertical INPUT.
3. Set both HORIZ. DISPLAY switches to Time Base A X1 and the Time Base A trigger SOURCE switch to UPPER BEAM. Trigger the displays with the Time Base A triggering controls.
4. Adjust the sweep rate with the TIME/CM and VARIABLE controls so that 1 cycle of the reference waveform covers 8 cm of the graticule, to calibrate the sweep at 45°/cm (see Fig. 3-7).

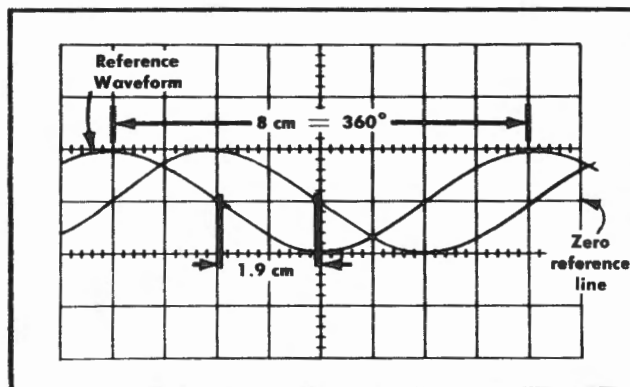


Fig. 3-7. Phase-difference measurement from a linear dual beam display calibrated at 45°/cm.

Example: 1.9 cm × 45°/cm = 81°.

The second signal lags the reference waveform by 81°.

5. Position both waveforms to center on the middle horizontal graticule line. Adjust the trigger LEVEL control so the reference waveform starts positive slightly below the centerline.
6. For phase angles up to 90°, the measurement should be made with the HORIZ. DISPLAY switch set at X.2 for

maximum accuracy. For phase angles greater than 90° , measurements must be made with the HORIZ. DISPLAY switch set at X1. Measure the horizontal distance in centimeters between corresponding points on the two phases.

7. Multiply the centimeters of horizontal displacement by the calibrated sweep rate (e.g. $45^\circ/\text{cm}$) to obtain the phase angle in degrees. With the HORIZ. DISPLAY switch set to X2, the sweep is calibrated at $9^\circ/\text{cm}$.

The "leading" waveform is generally considered to be the one to the left on the crt display, though this may not be the reference waveform. If the second waveform lies to the left, it leads the reference signal by the phase angle; if it lies to the right, it lags the reference signal.

More precise measurements can be made of very small phase angles, after setting up the display as described, by increasing the sweep rate by a factor of 2 or more with the TIME/CM switch. Do not change the position of the VARIABLE control. The sweep rate in degrees/cm will then change to include this increase. For example, if the sweep rate is increased by a factor of 10 (with the HORIZ. DISPLAY switch at X1), the calibrated rate will then be $4.5^\circ/\text{cm}$.

The delayed sweep mode can also be used to measure the time interval between phases by using the brightened portion of the display as a time marker. Set up the dual-beam display exactly as described above, using Time Base A to drive both beams. Set the Time Base B TIME/CM switch to SWEEPS ONCE FOR EACH 'A' DLY'D TRIG. The brightened portion of the display can then be positioned on the displays and the horizontal displacement read from the 1-10 MULTIPLIER dial.

Multi-Trace Method

Phase measurements made with multi-trace plug-in units are quite similar to those made with dual-beam operation, as described above. The beams will not need to be registered unless the instrument is being operated in both dual-beam and multi-trace mode.

Triggering from one source will be required. This can usually be provided by setting the trigger SOURCE switch to EXT. and applying an external time-related triggering signal. In this case, the trigger signal is actually the reference signal. The input signals are then compared directly to each other and indirectly to the triggering signal.

If a multi-trace plug-in unit with single-channel triggering is used, this method should be used rather than external triggering. Apply the reference signal to the channel with trigger pickoff. Set the trigger SOURCE to UPPER BEAM PLUG-IN or LOWER BEAM PLUG-IN, depending on the location of the multi-trace unit. The triggering signal will then be applied through wiring in the Type 555 to trigger the crt display only from the reference signal.

X-Y Method

To measure the phase angle between two sine-wave signals with frequencies up to 300 kc, the X-Y mode of operation may be used. In this mode, one of the sine-wave signals provides horizontal deflection of the crt beam, while the other signal provides vertical deflection. The phase angle between the two signals can then be determined from the lissajous figure displayed.

1. Connect one of the sine-wave signals to the vertical INPUT connector, and the other signal to the rear-panel EXT. HORIZ. INPUT connector of the same beam.

2. Set the HORIZ. DISPLAY switch to one of the EXT. ATTEN positions.

3. Position the trace on the crt screen and adjust the deflection factors to produce approximately 4 cm of deflection in each direction. The EXT. ATTEN X1 and EXT. ATTEN X10 positions of the HORIZ. DISPLAY switch set the attenuation range of the external horizontal input, and the rear-panel EXT. HORIZ. GAIN control adjusts the horizontal deflection factor over a 1-to-10 range.

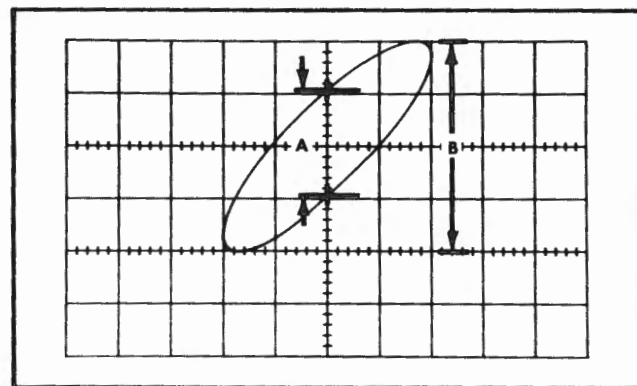


Fig. 3-8. Phase-difference measurement from an X-Y display. Sine of

Phase angle (ϕ) = $\frac{A}{B}$ (in display above). Example:

$$\text{Sine } \phi = \frac{2 \text{ cm}}{4 \text{ cm}} = 0.5; \phi = 30^\circ.$$

4. Center the display in the viewing area and measure the two vertical distances A and B as indicated in Fig. 3-8. Distance A is the vertical measurement between the two points where the trace crosses the vertical centerline. Distance B is the maximum excursion of the display in the vertical direction.

5. Divide A by B to obtain the sine of the phase angle between the two signals. The angle can then be calculated from a trigonometric table, or from the sine scale on a slide rule.

If the display appears as a diagonal straight line, the two sine waves are either in phase (tilted upper right to lower left), or 180° out of phase (tilted upper left to lower right). If the display is a circle, the signals are 90° out of phase.

NOTES

SECTION 4

CIRCUIT DESCRIPTION

BLOCK DIAGRAM

Fig. 4-1 is a simplified block diagram of the Type 555 Oscilloscope and its plug-in units showing the interrelation between the various circuits of the system. The instrument has two completely independent vertical deflection systems—one for the Upper Beam and one for the Lower Beam—and two essentially identical horizontal deflection systems that can be cross-connected or interconnected to extend the versatility of the instrument.

An input signal can be applied to either or both of the vertical plug-in units, or two signals can be applied separately to the two vertical inputs. The signals are then amplified by the corresponding Vertical Amplifiers in the oscilloscope and the push-pull outputs of the Vertical Amplifiers are connected through delay lines to their respective vertical deflection plates in the crt. Each delay line provides sufficient delay of the input signal so the Time-Base circuits will have the crt beam unblanked and sweeping before the input signal reaches the vertical deflection plates. This delay allows the leading edge of fast-rising pulses to be displayed.

To present stable displays of the input signals, the Time-Base Trigger circuits must use triggering signals that are time-related to the input signals, for starting each sweep of the Time-Base Generator. The triggering signals may be selected from several sources: either of the Vertical Amplifiers; the external trigger INPUT connector; the line frequency waveform, or a multi-trace plug-in unit (such as the Type 1A1) with single-channel trigger pickoff.

Output pulses from the two Time-Base Trigger circuits are then applied to their corresponding Time-Base Generators to initiate the sweep-sawtooth waveforms. Each Time-Base Generator consists essentially of a gating circuit and a Miller integrator. The gating circuit starts and stops each cycle of the Time-Base Generator operation, whether the circuit is set for triggered or free running operation. The Miller circuit generates a linear sawtooth waveform that is applied to either or both of the Horizontal Amplifier circuits where it is amplified. The sawtooth outputs of the Horizontal Amplifiers are then applied push-pull to the corresponding sets of horizontal deflection plates in the crt to produce the time-base sweeps of the crt beams.

The start of the sweep produced by the Type 22A Time-Base Unit may be delayed by a selected time interval by using the sawtooth from the Type 21A to produce the triggering pulse in the Delay Pickoff circuit. This permits the sweep of Time Base B to occur at a known interval after the start of the Time Base A sweep.

External sweep signals may also be used for generating the horizontal deflection of the crt beam by applying the signals to either of the Horizontal Amplifiers through the corresponding External Horizontal Amplifier circuit.

The Amplitude Calibrator circuit produces a square-wave output waveform that can be used for checking the calibration of the vertical deflection systems or for adjusting the compensation of probes.

The Low-Voltage Power Supplies provide the operating voltages for all circuits except certain portions of the crt circuit. The low-voltage supplies consist of five regulated dc voltages and one unregulated dc voltage as well as regulated and unregulated ac filament supplies.

Operating voltages for the crt are provided by separate high-voltage power supplies contained in the crt circuit. In addition to the high-voltage supplies, the crt circuit contains the controls and circuitry that affect the intensity, geometry, astigmatism and focus of each beam of the crt display.

VERTICAL DEFLECTION SYSTEM

Since the Upper Beam and Lower Beam vertical deflection systems are identical, only one of the systems will be described. The Upper Beam vertical deflection system is shown in block diagram form in Fig. 4-2. Circuit numbers in the following description are also those of the Upper Beam, but the description applies equally well to the Lower Beam.

An input signal to be displayed on the crt is applied to the input connector of the vertical plug-in unit. The plug-in unit provides a balanced push-pull output to the oscilloscope Vertical Amplifier circuit through the interconnecting plug and also provides positioning voltages for positioning the crt beam vertically on the screen. Some multi-trace plug-in units also provide a single-channel trigger signal through the interconnecting plug for triggering the time-base units.

The Vertical Amplifier in the Type 555 Oscilloscope consists of three dc-coupled push-pull stages, providing sufficient signal amplification to drive the delay line and one pair of vertical deflection plates in the crt. The passband of the vertical deflection system is dc to 30 mc, obtained through the use of low and high-frequency compensation and a distributed amplifier output stage. The push-pull output of the Vertical Amplifier is sent to the vertical deflection plates through a balanced delay line that is singly terminated at the input end.

The driver stage of the Vertical Amplifier applies a portion of the signal to the Trigger Pickoff circuit for use in triggering the sweep. The output is a single-ended signal in phase with the signal at the input of the vertical plug-in unit. This output is then applied through the trigger pickoff cathode follower to either or both of the Time-Base Trigger circuits.

Another push-pull signal is taken at the input to the distributed amplifier section and used by the beam-position indicator amplifier tubes to operate the beam-position neon bulbs. These bulbs indicate the relative position of the beam with respect to the center of the viewing area.

Input Stages

The push-pull input signal applied to the grids of the input amplifier tubes, V1014 and V1024, is amplified and sent to the driver stage. Amplification in the input amplifier is controlled by degeneration in the common cathode circuit. The GAIN ADJ control, R1027, is adjusted during calibration so

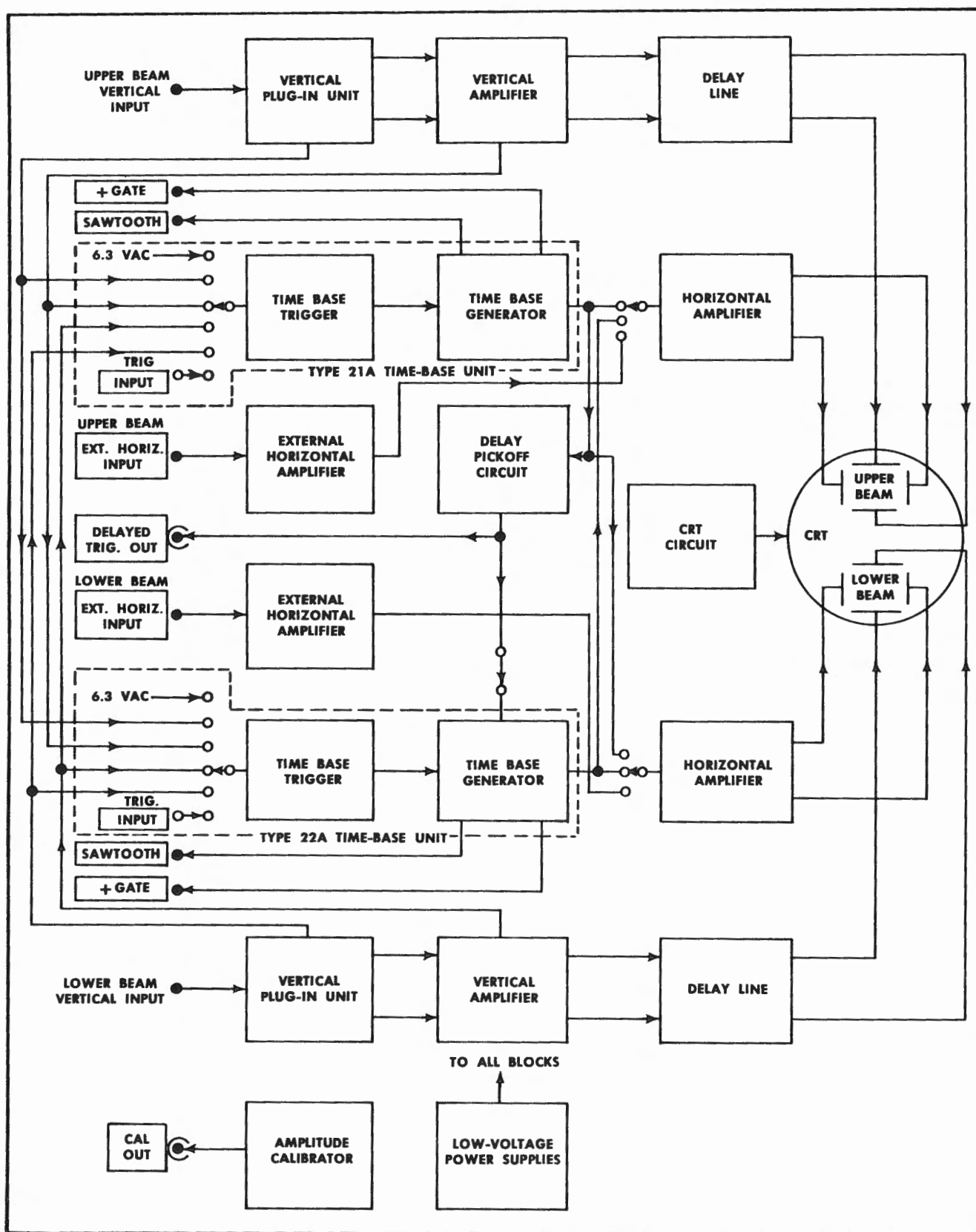


Fig. 4-1. Simplified block diagram of the Type 555 Oscilloscope.

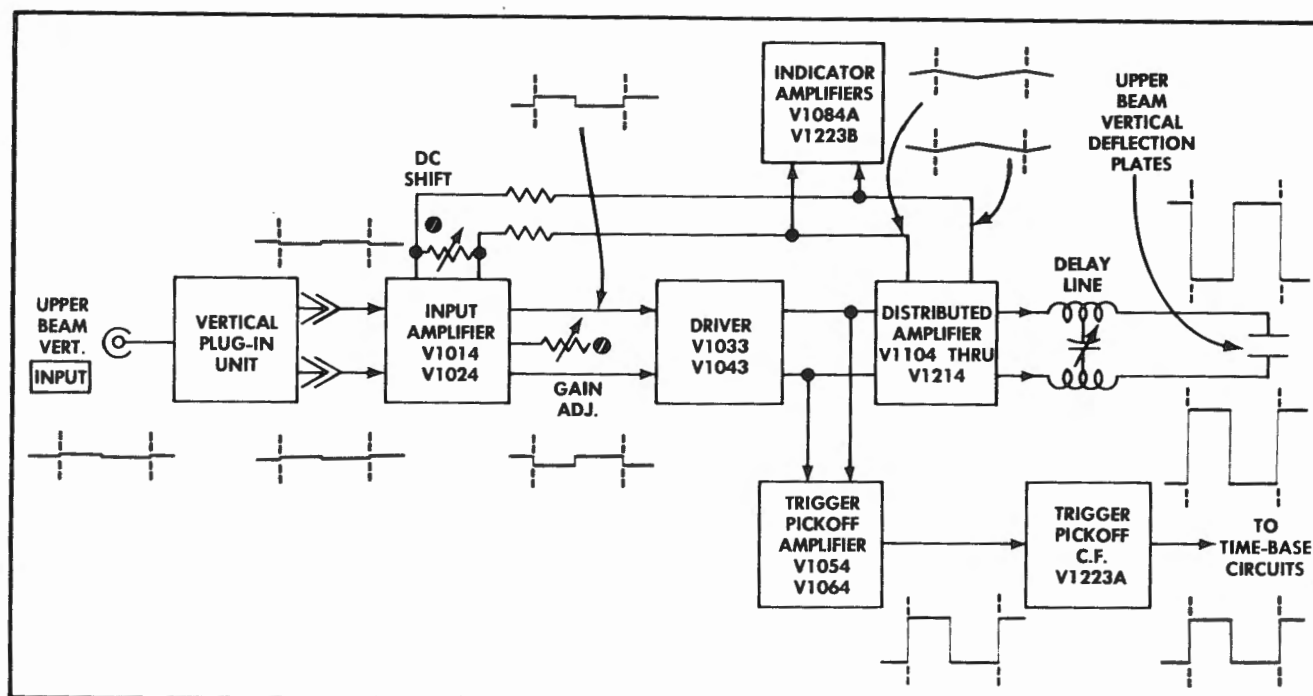


Fig. 4-2. Upper Beam vertical deflection system block diagram.

that the gain of the entire Vertical Amplifier will correspond to the calibrated deflection factors indicated on the front panel of the vertical plug-in unit. High-frequency compensation of the input amplifier is provided by inductors L1014 and L1024.

The driver stage consists of two pairs of cathode followers, V1033 and V1043, that isolate the distributed amplifier from the input amplifier and provide the necessary low-impedance drive for the grid line of the distributed amplifier. Compensation of the high frequency signals is provided by inductors L1036 and L1046 in the driver stage.

Output Stages

The push-pull signal from the driver stage is applied through the grid lines to each section of the six-section distributed amplifier, V1104 through V1214. The tapped inductors in the plate and grid transmission lines compensate for capacitance between sections of the distributed amplifier and also provide a slight delay of the signal as it passes through the circuit. Since the delay in the plate line is equal to that in the grid line, the amplified signal appears at the plate of each tube and is added to the signal amplitude just as the signal traveling along the plate line toward the delay line reaches that stage of the distributed amplifier. The output of the distributed amplifier is then connected to the vertical deflection plates through the 1200-ohm delay line. Adjustable capacitors along the delay line provide adjustment of the line characteristics for minimum distortion of the signal. A total of about 200 nanoseconds of signal delay is provided, with approximately 15 nanoseconds of delay occurring in the Vertical Amplifier and 185 nanoseconds of delay in the delay line.

The reverse termination network, shown on the Vertical Amplifier diagram presents a constant impedance over the frequency range of the instrument. The two resistors, R1071 and R1073, are divided into three sections each approximating a distributed termination. The termination is frequency compensated by the variable capacitors and inductors, C1075, C1077, C1078, L1071 and L1073.

Dc shift that results from a difference in transconductance of the amplifier tubes is normally less at dc and low frequencies than at mid and high frequencies. Compensation for this difference is provided by a low-frequency boost network on each side of the amplifier and by a small amount of positive feedback applied from the plate lines to the plate circuits in the input amplifier. The boost circuits, C1093B-R1090 and C1093D-R1095, increase the resistance of the reverse termination at low frequencies. The positive feedback circuits for extremely low frequency and dc compensation consist of R1092, R1094 and C1093A on one side, and R1097, R1099 and C1093C on the other. The DC SHIFT control, R1091, is connected between the two networks to balance the compensation.

Beam-Position Indicators

Current through the indicator amplifier tubes, V1084A and V1223B, is determined by the relative voltages on the plate lines of the distributed amplifier. These tubes in turn set the voltages across the beam indicator neon bulbs, B1083 and B1227. When the crt beam is centered vertically, neither tube is conducting. As the beam is positioned up or down, current through one of the tubes increases, causing one of the neon bulbs to light. Thus the neon that lights indicates the direction the crt beam has been positioned away from the center of the crt screen, whether the beam is visible or not.

Trigger Pickoff

The Trigger Pickoff circuit consists of an amplifier stage and an output cathode follower. The amplifier tubes, V1054 and V1064, monitor the vertical signal from the two grid lines, amplify and invert the signals, and combine them to provide the output signal. The single-ended output is coupled through V1223A to the interconnecting wiring of the oscilloscope for application to the Time-Base Trigger circuits where it can be used to trigger the display.

TIME-BASE TRIGGER

The basic function of the Time-Base Trigger circuit is to provide constant-amplitude negative spikes that are time-related to the input signal for starting each horizontal sweep at the proper time to present a stable display.

The Type 21A and the Type 22A have similar Time-Base Trigger circuits which operate on input signals up to 30 mc. Each of the circuits, as shown in the block diagram (Fig. 4-3), consists essentially of a vacuum-tube comparator, an emitter-coupled transistor current amplifier, a pulse generator, a countdown circuit and an output pulse amplifier. Refer to the Time-Base Trigger schematic diagram in the back of this manual during the following description.

Trigger Input

The SOURCE switch, SW8, at the input to the circuit provides selection of the trigger signal from one of six possible

sources: either of the Vertical Amplifier trigger pickoff circuits; either of the vertical plug-in units; the line frequency, or an external signal applied through the trigger INPUT connector. Use of the plug-in units for triggering sources is limited to operation with multi-trace plug-in units with internal trigger pickoff circuits. The line-frequency signal is taken from the 6.3 volt regulated filament supply and filtered by R5 and C5 to remove some of the rms regulator distortion.

The TRIG DC LEVEL controls, R3 and R8, set the dc levels of the inputs from the Vertical Amplifier at zero volts for dc-coupling of the internal signals. The attenuators associated with the DC TRIG LEVEL controls provide compensation for high-frequency triggering signals. The COUPLING switch, SW10, provides either ac- or dc-coupling of the trigger signal, and the trigger SOURCE switch, SW22, permits triggering to be done on either the positive-going or the negative-going slope of the selected signal.

Comparator and Difference Amplifier

The trigger comparator circuit consists of a cathode-coupled vacuum tube pair, V24A and V24B. The input triggering signal is applied to one of the grids and compared to a dc voltage on the other grid. The comparison voltage is provided by the trigger LEVEL and VERNIER controls, R17 and R21. The LEVEL control can vary the comparison voltage by about ± 10 volts, and the VERNIER control has a range of about ± 1 volt. When both of the controls are centered, the voltage is approximately zero.

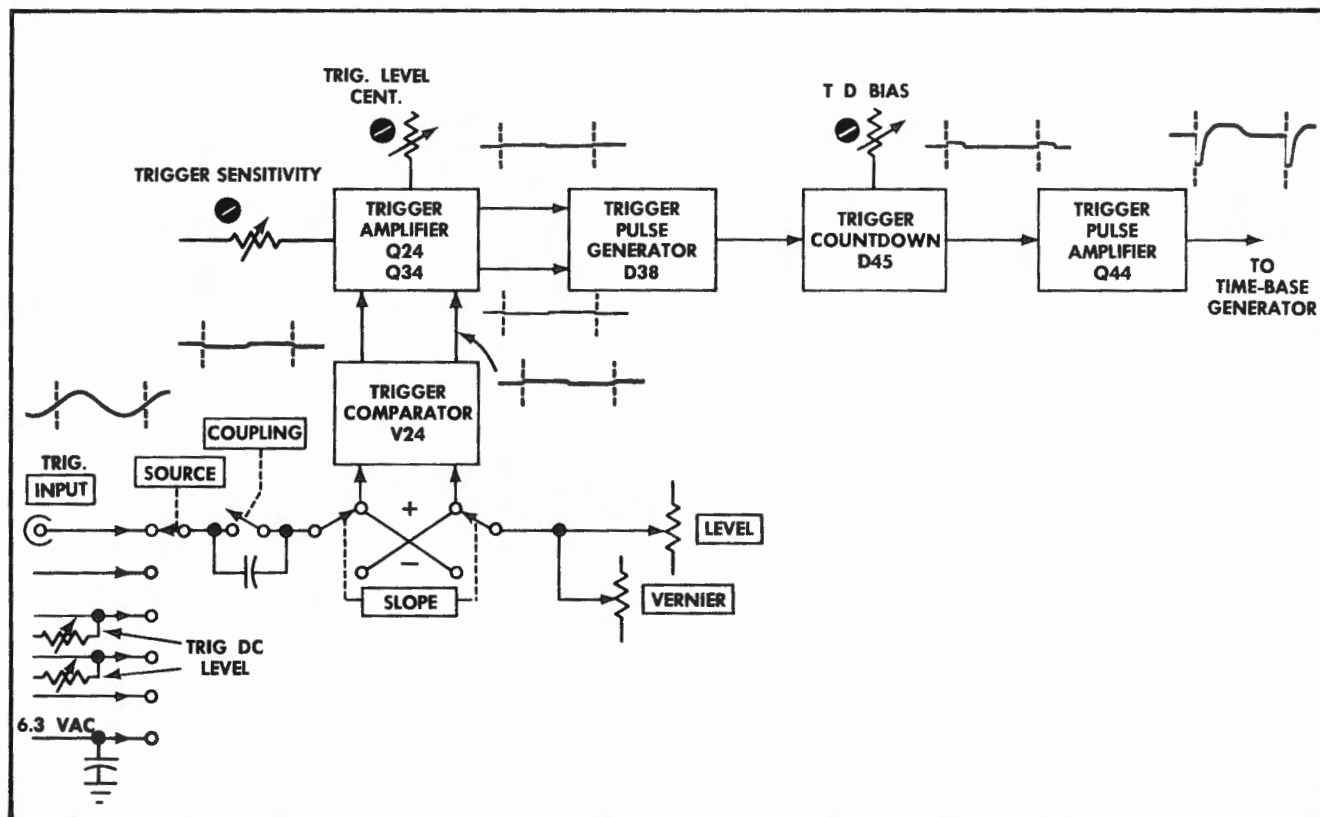


Fig. 4-3. Time-Base Trigger block diagram.

To illustrate the operation of the circuit, assume that the SLOPE switch, SW22, is set to + and the trigger level voltage is set slightly positive. The comparison voltage from the trigger level circuit is then connected to the grid of V24B and the triggering signal is applied to the grid of V24A. V24B will be conducting more heavily than V24A, D24 will be conducting, D25 will be reverse biased and current through Q24 will be greater than that through Q34. When the level of the input triggering signal becomes more positive than the comparison voltage, current through V24A becomes greater than that through V24B. The resulting current and voltage change in the plate circuits of V24A and V24B is applied to the transistor pair, Q24 and Q34. As D24 becomes reverse-biased and D25 begins to conduct, the voltage amplitude of the push-pull signal applied to Q24 and Q34 is limited to the sum of the bias voltages of D24 and D25. Thus the circuit is able to amplify and operate on small triggering signals, but large signals are clipped so they will not overdrive the circuit.

The signal applied to the base circuits of the transistor pair causes current to increase through Q34 and to decrease through Q24. The push-pull current pulse existing between the collectors of the transistor pair is sent through tunnel diode D38, causing it to switch rapidly to its high voltage state as soon as the current reaches approximately 10 ma.

If the SLOPE switch had been set at — and the triggering level voltage set slightly negative, a push-pull current pulse would have been sent through D38 in exactly the same manner. In that case, however, the switching pulse would have occurred on the negative slope of the input signal, as the trigger source voltage on the grid of V24B became more negative than the comparison voltage at the grid of V24A. The TRIG SENS control, R25, and the TRIG LEVEL CENT control, R26, are adjusted to set the bias on Q24 and Q34 so the circuit will trigger equally in + and — polarity on signal amplitudes down to the minimum specified amplitude. (In instruments having S/N's 7000-10999, the TRIG LEVEL CENT control, R26, balances the base voltages on Q24 and Q34 so that their bias currents are equal).

Pulse Generator and Amplifier

(S/N 11000-up)

Bias current for high-frequency tunnel diode D38 is supplied primarily through Q34, R34, R39 and R38, setting D38 near its switching level, but in its low-voltage state. Bias current for countdown tunnel diode D45 is adjusted by means of R44 (TD BIAS) so that this tunnel diode is also in the low-voltage state near its switching point.

Current through D40 and R36 sets the voltage at the anode of series diode D42 at about +0.6 volt. With the voltage on the cathode of D42 set at about +0.5 volt, this diode has a forward voltage applied but not enough to turn it on by more than a few microamps.

When diode D38 is switched to its high-voltage state by the current pulse from the transistor pair, the fast positive-going output pulse applied through C38 quickly forward biases D42, switching D45 to its high-voltage state. As D45 switches, the positive-going voltage on the cathode of D42 reverse biases this diode and it returns to its non-conducting state.

Output inverter transistor Q44, which is quiescently biased to conduct slightly, is turned on hard by the pulse from D45 as the tunnel diode switches to the high voltage state. The resulting negative-going pulse at the collector of Q44, as the transistor saturates, is the output trigger pulse to be used by the Time-Base Generator circuit.

Reset of D38

(S/N 11000-up)

When the input triggering signal at the comparator drops somewhat below the comparison voltage, D38 is reset to its low-voltage state by the amplifier transistors. The negative-going pulse that appears at the anode of D38 as the diode resets is blocked by D42 and does not reach the countdown circuit. Thus, the output trigger pulse is a fast 10-volt negative step as Q44 saturates, followed by a slow positive rise as Q44 returns to its initial bias conditions.

(S/N 7000-10999)

Bias current for tunnel diode D38 is supplied primarily through D45, R41 and R38, setting both D38 and D45 near their switching levels (see Fig. 4-4). This current is adjusted with the TD BIAS control, R44, during calibration. Resistor R36 sets the lower switching level of D38.

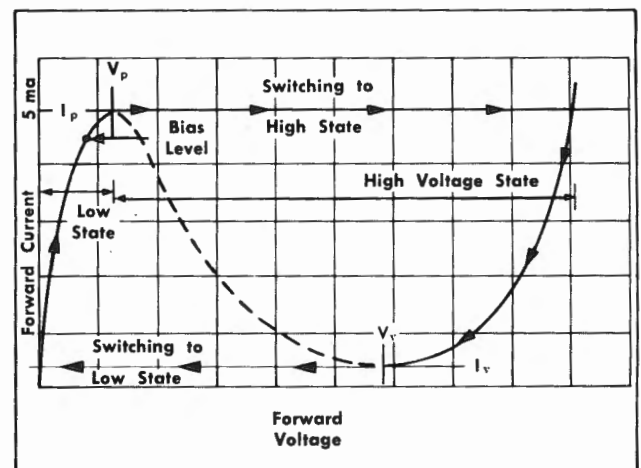


Fig. 4-4. Characteristic curve for tunnel diodes D38 and D45.

When diode D38 is switched to its high voltage state by the current pulse from the transistor pair, the resulting voltage pulse is differentiated by C38, C40, R40 and the impedance of T40. The small pulse is then applied through D40 to the countdown tunnel diode, D45, switching it to its high state. The output amplifier-inverter, Q44, is quiescently biased to conduct slightly. As D45 switches to its high state, the positive-going pulse applied to the base of Q44 causes the transistor to saturate. The resulting fast negative-going pulse at the collector is the output trigger pulse to be used by the Time-Base Generator circuit.

Trigger Countdown

(S/N 11000-up)

The input comparator and amplifier stages of the Time-Base Trigger circuit, as well as D38 and D40, can follow changes

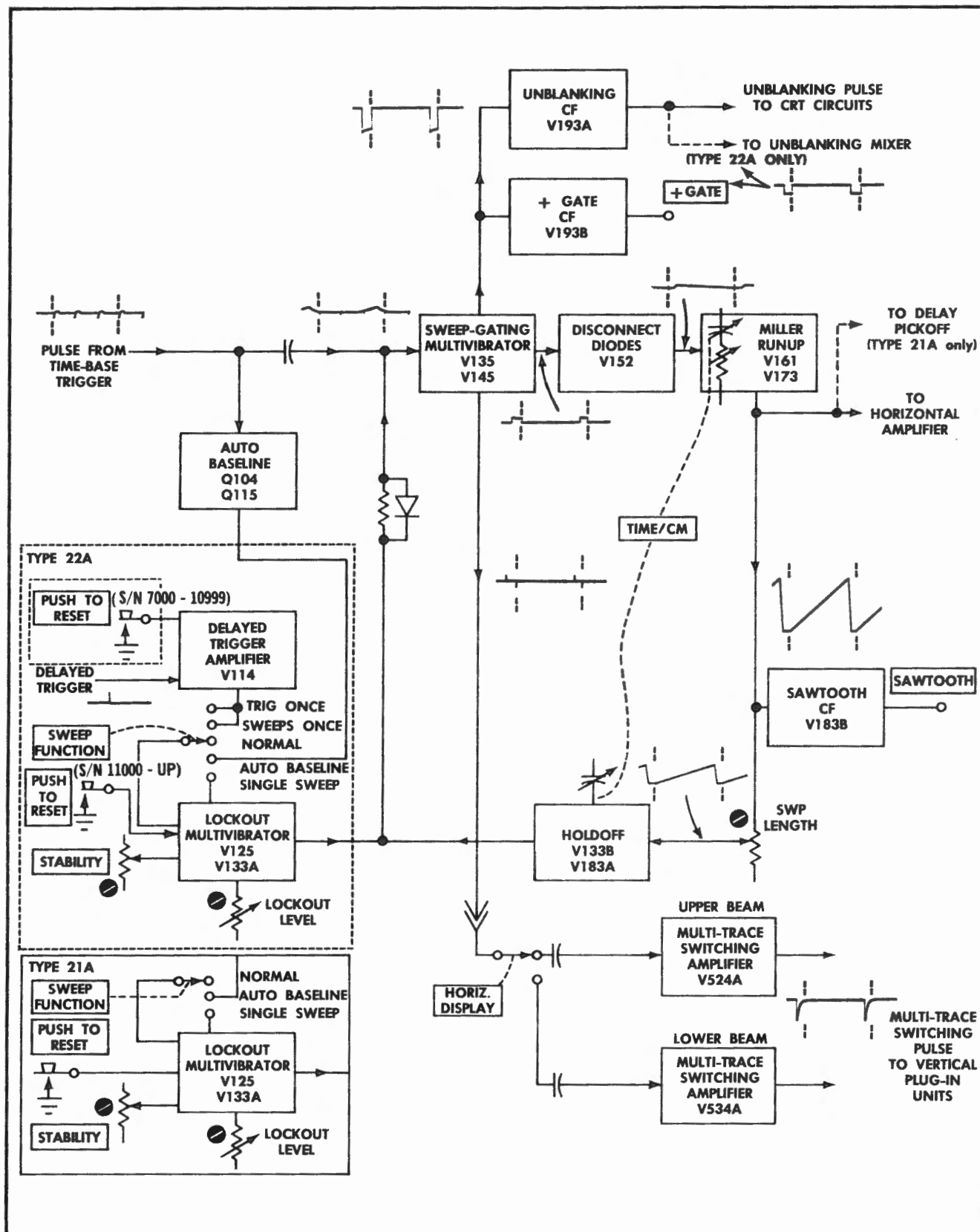


Fig. 4-5. Time-Base Generator block diagram showing differences between the Type 21A and the Type 22A.

in the input trigger circuit to well above 30 mc. Thus the frequency of the pulses applied through C38 can be as high as 30 mc. The maximum repetition rate of the Time-Base Generator circuit, however, is about 150 kc and that circuit cannot count down well from high frequencies. Therefore, countdown of the trigger pulses is provided by tunnel diode D45 and associated components limiting the repetition rate of trigger pulses to the Time-Base Generator circuit to less than 70 kc.

This tunnel diode circuit accomplishes the required count-down by setting the cycle time of the circuit, from the instant of triggering to next instant of triggerability at approximately 14.3 μ sec. When D45 is triggered by a pulse from D38, it switches to its high-voltage state, but since the circuit of D45 is a monostable configuration, D45 immediately attempts to switch back to its low-voltage state. The current and voltage decrease along the tunnel diode curve at a rate determined by the L/R time constant of L42 and the resistance of the circuit. When the current has decreased to the valley current of the tunnel diode curve, D45 switches back to its low voltage stage, then recovers to its bias level at the L/R time constant of the circuit at that time. The total cycle time of the circuit is adjusted to be 14.3 μ sec (70 kc) by the setting of R44 (TD BIAS).

(S/N 7000-10999)

The input comparator and amplifier stages of the Time-Base Trigger circuit, as well as D38 and D40, can follow changes in the input trigger signal to well above 30 mc. Thus, the frequency of the constant-amplitude pulses applied to D45 can be as high as 30 mc. The maximum repetition rate of the Time-Base Generator circuit is about 150 kc, and it cannot "count down" well from high frequencies. Therefore countdown of the trigger pulses is provided by D45 to limit the repetition rate of trigger pulses to the Time-Base Generator circuit to less than 70 kc.

Countdown is accomplished by making the cycle time of D45, from the instant of triggering to the next instant of triggerability, about 14 μ sec. When D45 is triggered by a pulse from D38, it switches to its high voltage state, but this is an unstable state so the voltage and current immediately begin to decrease along the tunnel diode curve at a rate determined by the L/R time constant of L42 and the resistance of the circuit. D45 switches back to its low voltage state when it reaches the valley current, then recovers to its bias point at the L/R time constant of the circuit at that time. Since the total cycle time is about 14 μ sec, the maximum repetition rate of the countdown circuit is about 70 kc.

Reset

When the input triggering signal at the comparator drops somewhat below the comparison voltage, D38 resets to its initial state. The negative voltage pulse through T40 is blocked by D40 and does not reach the countdown circuit. Thus the output trigger pulse is a fast 10-volt negative step as Q44 saturates, followed by a slow positive rise as the output is differentiated and Q44 returns to its initial bias conditions.

TIME-BASE GENERATORS

The Time-Base Generator circuits in the Type 21A and the Type 22A are essentially identical except for portions related

to the delayed sweep. Fig. 4-5 is a block diagram of the Time-Base Generator showing the basic circuits and differences between the two units. The following circuit description applies to both generators. Operation of the delayed sweep circuitry is described later in this section.

Trigger signals received from the Time-Base Trigger circuit are applied to the auto baseline multivibrator and through a differentiating circuit to the sweep-gating multivibrator. Whenever the Time-Base circuit operates, whether triggered or free running, it produces four output signals:

1. A 150-volt positive-going sweep sawtooth waveform that can be coupled through the HORIZ. DISPLAY switches to either or both of the Horizontal Amplifiers. The sawtooth output is coupled to the SAWTOOTH connector through an output cathode follower, and the Time Base A sawtooth is also connected to the Delay Pickoff circuit.
2. A positive-going 65-volt unblanking waveform, with the same duration as the sawtooth rise, coupled through the HORIZ. DISPLAY switches to floating high-voltage negative supplies in either or both sides of the crt circuit. The unblanking waveform unblanks the crt beam(s) being deflected by the Time-Base Unit during the sweep.
3. A positive 25-volt +gate waveform with the same duration as the sawtooth rise, available at the front-panel +GATE connector for external use.
4. A negative-going 12-volt multi-trace sync pulse with the same duration as the sawtooth rise, coupled through the HORIZ. DISPLAY switches to either or both of the vertical plug-in units. The trailing edge of the pulse causes a multi-trace plug-in unit to switch channels when operated in the alternate mode.

Each cycle of events is either started by a trigger pulse from the Time-Base Trigger circuit, or is started by the end of the previous cycle when the circuit is set for free-run operation. Triggered operation is used for most applications. The Time-Base Generator can also be disabled so that the circuit will not operate. The desired mode of operation is obtained through the appropriate setting of the SWEEP FUNCTION switch and the trigger LEVEL and VERNIER controls.

The auto baseline circuit provides free-run operation of the sweep in the absence of trigger pulses, and the lockout multivibrator provides single sweep operation. The sweep-gating multivibrator is a two-state electronic switch that turns the disconnect diodes on and off. When the diodes are on, the output of the Time-Base Generator is clamped slightly below ground. When the diodes are cut off, the Miller runup circuit is allowed to produce a sweep sawtooth signal. A portion of the sawtooth waveform is fed back to the sweep-gating multivibrator through the hold off circuit, forming the holdoff waveform. When the rise of the holdoff waveform reaches a preset amplitude, the sweep-gating multivibrator resets, switching the disconnect diodes on. The Miller runup circuit then resets, forming the retrace or falling portion of the sawtooth. The retrace portion of the feedback sawtooth sample is delayed by the holdoff circuit, preventing the generator from beginning the next cycle of operation until the circuits have stabilized.

The dc level at the input of the sweep-gating multivibrator is controlled by the lockout multivibrator, the STABILITY control, the auto baseline circuit and the holdoff waveform. In

Circuit Description — Type 555/21A/22A

normal triggered operation, one half of the lockout multivibrator serves as a cathode follower to hold the input voltage at the "triggerable" level.

In the following detailed circuit description, refer to the Type 21A Time-Base Generator schematic diagram in the back of this manual. Unless otherwise stated, the SWEEP FUNCTION switch is set to NORMAL and the trigger LEVEL and VERNIER controls are set for triggered operation.

Quiescent Conditions

In the quiescent state with the generator in a triggerable condition but no sweep being generated, the circuit conditions are as follows:

Sweep Gating Multivibrator—V135A is conducting and V145 is cut off. The STABILITY control, operating through cathode follower V125, sets the grid voltage of V135A at about -50 volts. The plate voltage of V135A, applied through cathode follower V135B sets the grid of V145 about 5 volts more negative than the grid of V135A, so V135A draws all the current available from the common cathode circuit. The cathode voltage of V135B sets the voltage at the grids of V193A and V193B so that V193A is conducting and V193B is cut off. Thus the blanking voltage to the crt from the cathode of V193A is at about -45 volts, and the +GATE output at the cathode of V193B is held at ground. With V145 cut off, its plate voltage of about -3 volts keeps the disconnect diodes turned on.

Disconnect Diodes—V152A and V152B are conducting. V152A clamps the sawtooth output at about -3.5 volts at the cathode of V173, to provide a stable starting voltage for the sawtooth. V152B clamps the grid of V161 at about -2.5 volts.

Miller Runup Circuit—V161 is conducting heavily with its grid held at about -2.5 volts and its plate voltage at about $+40$ volts. V173 is cut off with a voltage of about -12 volts on its grid, set by the plate voltage of V161 and the divider, B167 and R167.

Holdoff Circuit—V183A is conducting and V133B is cut off. Voltage applied to V183A through the SWP LENGTH control sets the voltage at its grid at about -95 volts and its cathode at about -85 volts. This voltage, which is connected to the grid of V133B, is about 35 volts more negative than the -50 volts on the cathode of V133B set by the stability control circuit, so the tube is cut off.

Lockout Multivibrator—V125 is conducting and V133A is cut off. The circuit is essentially inoperative, though V125 is serving as a cathode follower for the stability voltage.

Auto Baseline Circuit—V115A and Q104 are conducting and V115B is cut off. With the grid of V115A held at about $+18$ volts (with SWEEP FUNCTION at NORMAL), negative trigger pulses applied through D108 cannot cause the circuit to operate.

Cycle of Operation

a. Gating

When the negative-going pulse is received from the Time-Base Trigger circuit at the grid of V135A, the sweep-gating multivibrator switches states. The switching action begins as

the trigger pulse at the plate of V135A is applied to the grid of V145 through cathode follower V135B, starting conduction of current through V145 and decreasing current from the common cathode through V135A. This regenerative action quickly switches the state of the multivibrator so that V135A is cut off and V145 is conducting heavily. The positive-going portion of the trigger signal is clipped by diode D132 and has no effect on the sweep-gating multivibrator.

When V135A cuts off, the voltage at the cathode of V135B rises sharply. This voltage step is coupled to the unblanking and +gate cathode followers, V193A and V193B, causing them to unblank the crt beam and start the +gate output pulse.

With V145 now in conduction, its plate voltage has dropped to a new level of about -6 volts. This negative voltage step lowers the voltage on the plates of the disconnect diodes to a value more negative than their cathodes, and causes the tubes to cut off.

b. Runup

Current through the timing resistor, R160, that had been conducted by V152B, is now diverted and begins to charge the timing capacitor, C160, toward -150 volts. The initial negative change in voltage at the grid of the Miller tube, V161, is amplified by a factor of about 200 and appears as a positive-going voltage at the plate of the tube. This amplified change is coupled back through the dc voltage-dropping bulb, B167, and cathode follower V173 to the output side of the timing capacitor, tending to oppose any change at the grid side of the capacitor. The feedback action continues throughout the sawtooth rise, limiting the total swing at the grid to less than 1 volt. With the grid of V161 held at a nearly constant voltage level, the voltage across the timing resistor remains essentially unchanged. Current through the

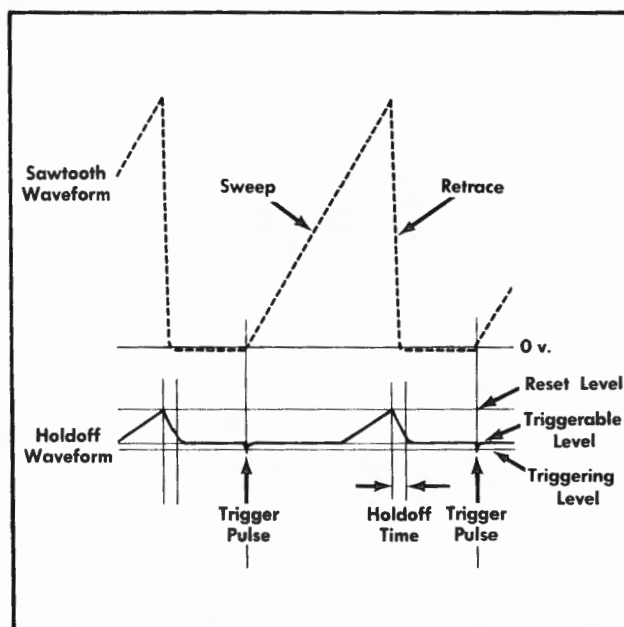


Fig. 4-6. Cycle of events at grid of V135A, related to output sawtooth waveform.

resistor is therefore constant and the timing capacitor charges linearly. The resulting voltage change at the cathodes of V173 is a linear 150-volt sawtooth that is capable of driving the Horizontal Amplifier. The rate of rise of the sawtooth is determined by the RC time constant of the particular timing resistor and timing capacitor combination selected with the TIME/CM switch, SW160. The fast sweep rates are also accurately calibrated with variable capacitors.

An attenuated portion of the positive-going voltage sawtooth waveform is also fed back to the grid of V183A in the holdoff circuit. The amount of attenuation of the waveform is set by the SWP LENGTH control, R176.

As the voltage rises at the grid of V183A, the cathode follows the grid voltage, causing the holdoff capacitor to charge through R181. The cathode voltage is also coupled to the grid of V133B. When the grid of V133B becomes slightly more positive than the -50 volts set at the cathode by the stability circuit, V133B begins to conduct. Since V125 is cathode-coupled to V133B, V125 cuts off as V133B starts to conduct, and the attenuated sawtooth above the stability level is coupled through V133B to the grid of V135A at the input to the sweep-gating multivibrator. Figure 4-6 relates the cycle of events at the grid of V135A to the output sawtooth waveform.

c. Reset

The holdoff waveform rises until it reaches the reset level, which is slightly more positive than the common cathode voltage set by the grid of V145. V135A then begins to conduct, diverting current from V145 and causing the multivibrator to switch back to its original state.

The negative-going voltage step at the cathode of V135B as the multivibrator switches is coupled through V193A and V193B to end the $+$ gate pulse and blank the crt for retrace. The positive-going voltage at the screen grid of V145 is connected through the appropriate multi-trace switching amplifier, V524A or V534A, to the vertical plug-in unit for alternate-trace switching during retrace.

As V145 cuts off, its plate rises to about -3 volts again, bringing V152B into conduction. The voltage at the grid of V161 rises rapidly and the plate voltage drops. The grid and cathode voltages on V173 follow the plate of V161 to form the falling portion, or retrace, of the sawtooth waveform. When the cathodes of V173 reach about -3.5 volts, V152A conducts, stopping the voltage fall and clamping the output voltage at that level.

The portion of the sawtooth waveform coupled back to the holdoff circuit is applied to the grid of V183A, reducing current through the tube. The holdoff capacitor, which had been charging during the sweep, now discharges through R181. The voltage fall is thus retarded at the grid of V133B and hence at its cathode. When the grid voltage of V133B reaches the level set by the stability circuit, V125 conducts and V133B cuts off. The voltage at the grid of V135A is then set again at the triggerable level and the Time-Base Generator is ready to repeat the cycle of the sawtooth waveform.

The holdoff time at each sweep rate is set for the required recovery time of the runup circuit by the holdoff capacitor selected with the TIME/CM switch (see the Timing Switch schematic diagram). The stability voltage, applied to the grid of V135A through cathode follower V125 is set with the STABILITY

control, R111, so that with the SWEEP FUNCTION switch set at NORMAL, the minimum voltage at the grid of V135A will be at the "triggerable" level, about 2 volts above the level required to cut off V135A and switch the multivibrator. An incoming trigger from the Time-Base Trigger circuit will then drive the grid below the switching level, causing the multivibrator to switch and start a cycle of the sawtooth waveform.

Multi-Trace Sync

Pulses from the sweep-gating multivibrators are applied to the vertical plug-in units to switch between channels when using a multi-trace vertical plug-in unit in the alternate mode. Channel switching is accomplished while the crt beam is blanked during retrace of the sweep.

The waveform from the screen grid of V145 in the sweep-gating multivibrator of either time-base unit may be connected through the HORIZ. DISPLAY switches to the grids of either or both of the multi-trace switching amplifiers, V524A and V534A, shown on the Horizontal Display Switching schematic diagram. The waveform is differentiated by the network at the grid of each tube. Since both the cathode and plate voltages are supplied by the vertical plug-in unit, the operation of V524A or V534A depends on the multi-trace unit being used. In general, the tube is conducting when the plug-in unit is in alternate mode and inoperative in all other modes. When V524A (or V534A) is conducting, the multi-trace sync pulse from the sweep-gating multivibrator is applied to the plug-in unit, either as an amplified negative-going pulse taken from the plate, or as a small positive-going pulse taken from the cathode with the tube connected as a cathode follower.

Auto Baseline

The auto baseline circuit in each of the time-base units is designed to produce a free-running trace on the crt screen when no trigger pulses are being applied to the Time-Base Generator. The operation of the auto baseline circuit in the Type 22A is identical to that of the one in the Type 21A; however, the circuit numbers of many of the components are not the same in the two units. Refer to the schematic diagram of the Type 21A Time-Base Generator circuit during the following description.

The circuit is essentially a cathode-coupled monostable multivibrator, V115A and V115B, which turns transistor Q104 on and off to control the stability voltage at the grid of V125. When the SWEEP FUNCTION switch is set at any position except AUTO BASELINE, the positive voltage applied to the grid of V115A causes V115A to conduct and keeps V115B cut off. Current from the plate circuit of V115A biases Q104 into saturation, setting its collector at $+100$ volts. This voltage is then applied to the stability circuit through R115. The STABILITY control is set during calibration to place the grid of V125 at about -50 volts while Q104 is in saturation.

When the SWEEP FUNCTION switch is in AUTO BASELINE and no trigger pulses are being applied to the Time-Base Generator circuit, the voltage on the grid of V115A is reduced to a level about 8 volts more negative than the grid of V115B. Thus V115B is conducting, V115A is cut off, and the voltage at the plate of V115A is positive enough to reverse bias the base-emitter junction of Q104, cutting off the transistor. The voltage at the collector of Q104 is about

+80 volts with the transistor turned off, or about 20 volts more negative than when Q104 is saturated. The stability voltage at the grid of V125 is proportionally more negative, and the lower limit of the holdoff waveform is allowed to drop below the triggering level of the sweep-gating multivibrator. With the holdoff waveform set at this level, the reset portion of each cycle of the holdoff waveform triggers a new sweep, causing the Time-Base Generator circuit to free run (see Fig. 4-7).

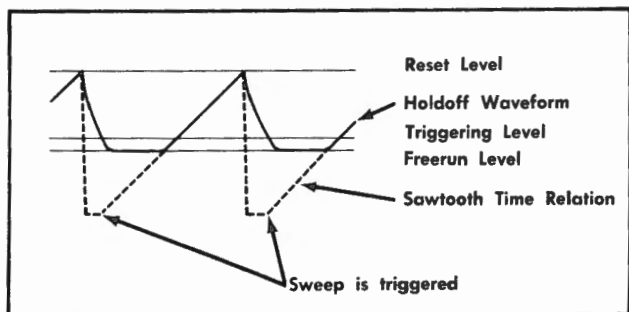


Fig. 4-7. Holdoff waveform at grid of V135A with Time-Base Generator set for free-run operation. SWEEP FUNCTION switch is at AUTO BASELINE and LEVEL control is fully clockwise.

The voltage at the grid of V115B is normally set at about +12 volts by current through R107 and D108, and through R49 and Q44 in the Time-Base Trigger circuit. When the SWEEP FUNCTION switch is in any position except AUTO BASELINE, negative trigger pulses applied through D108 only tend to hold V115B in cutoff. However, when the SWEEP FUNCTION switch is set to AUTO BASELINE V115B is turned on and negative pulses applied through D108 cut off V115B. As V115A turns on, the resulting negative-going voltage at the plate of V115A is coupled back to the grid of V115B through C108 and drives V115B farther into cutoff. Following the trigger pulse, the voltage at the cathode of D108 returns immediately to about +12 volts. Therefore, as soon as the regenerative action of the multivibrator has ended, the grid of V115B also attempts to return to that voltage. The return to +12 volts is relatively slow, however, since D108 is now reverse biased, and C108 has to discharge through R107. As soon as the grid of V115B becomes more positive than the grid of V115A, the multivibrator reverts to its previous state, with V115B conducting and V115A cut off. The time constant of this monostable multivibrator is designed for a reset time of about 80 msec.

When the trigger pulse was applied and the multivibrator switched, the negative-going voltage at the plate of V115A started to charge C105 and also forward biased Q104, causing the transistor to saturate. The momentary charge on C105 stretches the pulse at the base of Q104, and the transistor is held in saturation for the duration of the stretched pulse. The resulting positive voltage applied to the grid of V125 raises the holdoff voltage from a free-running condition to a triggerable condition. As the stretched pulse on the base of Q104 ends, the transistor cuts off and the stability level again drops to a free-run condition, triggering the Time-Base Generator.

If trigger pulses are received at a rate faster than about 20 cycles per second, the voltage level on C105 and at the base of Q104 is held far enough negative to keep the

transistor saturated. Thus, at this triggering rate, the stability voltage is held positive and the lower limit of the holdoff waveform is held at the triggerable level. Triggering then occurs exactly the same as it would with the SWEEP FUNCTION switch at NORMAL.

Lockout Multivibrator

The lockout multivibrator circuit is designed to hold off the sweep of the crt beam under certain conditions by locking out operation of the Time-Base Generator circuit. This action permits observation of a single sweep of the crt beam, and also provides for delayed operation of the sweep in the Type 22A as described below under Delayed Sweep. Refer to the Type 21A schematic diagram during the following description.

With the SWEEP FUNCTION switch, SW128, set at NORMAL or AUTO BASELINE, the plate of V133A is disconnected from the positive supply; therefore, the tube is cut off and V125 is allowed to conduct. Under these conditions, V125 acts merely as a cathode follower between the stability voltage on its grid and the holdoff waveform on its cathode.

When the SWEEP FUNCTION switch is set to SINGLE SWEEP, the plate of V133A is connected to the +100 volt supply through R128. With power applied to both tubes, the circuit operates as a cathode-coupled bistable multivibrator. The voltage level on the grid of V133A is then set with the LOCKOUT LEVEL control, R125, so that when V133A is conducting, the minimum voltage of the holdoff waveform is at the "lockout" level, far enough positive that incoming trigger pulses cannot switch the sweep-gating multivibrator. The sweep is then disabled until the cathode voltage is allowed to drop.

(5/N 11000-up)

To produce a single sweep of the crt beam, the front-panel PUSH TO RESET button is pressed, connecting the junction of R101 and R116 to ground through R98. The positive-going voltage step at the grid of V125 turns on V125, causing V133A to turn off. This action arms the Lockout Multivibrator circuit. With V125 then controlling the cathode, as long as the PUSH TO RESET button is held in, the voltage at the grid of V135A is held too far positive for the sweep-gating multivibrator to be triggered. When the PUSH TO RESET button is then released, the level at the grid of V125 drops to the stability level determined by the STABILITY adjustment, placing the sweep-gating multivibrator in a triggerable condition. With V133A cut off, its plate voltage attempts to go to +100 volts, turning on the READY neon bulb which indicates that the Time-Base Generator is ready to produce a single sweep. The next trigger pulse that arrives at the sweep-gating multivibrator switches it, starting a new cycle of the sweep waveform (see Fig. 4-8).

(5/N 7000-10999)

To produce a single sweep of the crt beam, the front-panel PUSH TO RESET switch, SW101, is pressed. C102, which had been charged to +100 volts through R101, discharges to ground, applying a fast negative-going pulse through C123 to the grid of V133A. The pulse cuts off V133A, allowing V125 to turn on, and the negative-going voltage at the plate of V125, applied through C123, forces V133A farther into cutoff. With V125 then controlling the cathode, the voltage drops to the stability level on the grid of V125, which puts

the sweep-gating multivibrator into a triggerable state. With V133A cut off, its plate voltage attempts to go to +100 volts and the READY neon bulb lights, indicating that the Time-Base Generator is ready to produce a single sweep. The next trigger pulse that arrives at the sweep-gating multivibrator switches it, starting a cycle of the sweep waveform (see Fig. 4-8).

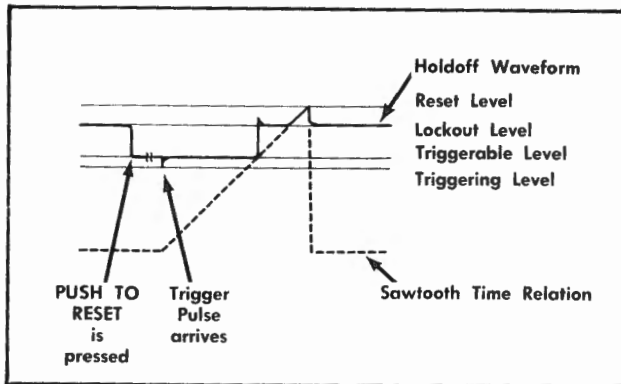


Fig. 4-8. Single sweep holdoff waveform, with SWEEP FUNCTION switch set at SINGLE SWEEP.

When the rising portion of the holdoff waveform at the cathode of V125 reaches the stability voltage on its grid, V125 cuts off and the multivibrator resets for single sweep operation. V133A turns on, the READY neon turns off as the plate voltage drops, and the cathode of V133A sets the voltage at the grid of V135A at the lockout level. As the sawtooth portion of the holdoff waveform rises above the lockout level, V133B takes control of the common cathode and cuts off V133A. The holdoff waveform rises to the reset level, then begins its retrace. When the waveform reaches the lockout level, V133A begins to conduct again and holds the voltage at the grid of V135A at that level. The sweep-gating multivibrator is thus locked out until the PUSH TO RESET button is pressed once more.

Delayed Sweep

A delayed trigger amplifier circuit in the Type 22A Time-Base Unit allows the delayed trigger from Time Base A (Type 21A) to be used in one of two modes to operate the lockout multivibrator in the Type 22A. In one mode the sweep becomes triggerable after receiving a delayed trigger pulse, and in the other mode the sweep is triggered by the lockout circuit as soon as a delayed trigger arrives.

The lockout multivibrator in the Type 22A operates in exactly the same manner as the one in the Type 21A when the SWEEP FUNCTION switch is in the NORMAL, AUTO BASELINE and SINGLE SWEEP positions. However, the pulse from the PUSH TO RESET switch is applied through V114, rather than being connected directly.

When the SWEEP FUNCTION switch, SW120, is set to TRIGGERABLE ONCE FOR EACH 'A' DLY'D TRIG, V133A is conducting and the multivibrator is set for single sweep operation, with the cathode voltage on V133A locking out the sweep. When the Time Base A sweep has run to a certain level, set by the DELAYED TRIGGER 1-10 MULTIPLIER control, a delayed trigger pulse is applied to the grid

of V114 in the Type 22A (Time Base B). The pulse is amplified by V114 and applied as a negative pulse to the grid of V133A. This pulse cuts off V133A, allowing V125 to set the cathode voltage at the triggerable level. The Type 22A will not sweep, however, until it receives a trigger pulse from its Time-Base Trigger circuit (see Fig. 4-9).

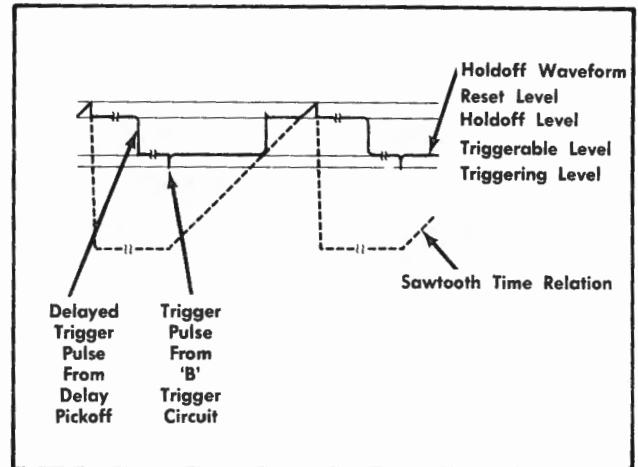


Fig. 4-9. Delayed sweep holdoff waveform with Type 22A SWEEP FUNCTION switch set at TRIGGERABLE ONCE FOR EACH 'A' DLY'D TRIG.

After the sweep has been triggered and starts to rise, the holdoff waveform resets the lockout multivibrator and the minimum level of the holdoff waveform is again set at the lockout level after retrace. The next sweep is then held off until another delayed trigger pulse is received during the next cycle of the Time Base A generator circuit, setting the sweep-gating multivibrator in the Type 22A into a triggerable condition again.

When the SWEEP FUNCTION switch is set to SWEEPS ONCE FOR EACH 'A' DLY'D TRIG, the lockout multivibrator switches the sweep-gating multivibrator, causing the Type 22A to produce one cycle of its output sawtooth as soon as it receives a delayed trigger pulse from Time Base A. All conditions are the same in this mode as in the triggerable delayed mode, except that the voltage on the grid of V125 is set at about -60 volts. This sets the lockout multivibrator into a monostable configuration. Incoming delayed trigger pulses are again applied by way of V114 to the grid of V133A, cutting that tube off and allowing V125 to conduct. The cathode drops to the voltage set by the grid of V125, which is now set below the triggering level of the sweep-gating multivibrator. This voltage step triggers the sweep-gating multivibrator, immediately starting the sweep of the Time-Base Generator (see Fig. 4-10). As soon as the regenerative action of the lockout multivibrator has ended, the grid of V133A returns to the level set by the LOCKOUT LEVEL control, setting the grid at the lockout level as before. V133A turns on, raising the cathode back to the lockout level. The sweep continues, then retrace occurs and the input grid of the sweep-gating multivibrator is held at the lockout level until another delayed trigger is received from Time Base A. Each time another delayed trigger pulse arrives, the lockout multivibrator will trigger the sweep, without waiting for a trigger from the Time-Base Trigger circuit.

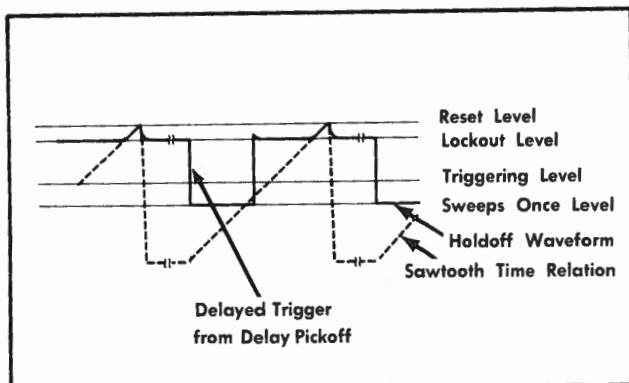


Fig. 4-10. Delayed sweep holdoff waveform with Type 22A SWEEP FUNCTION switch set at SWEEPS ONCE FOR EACH 'A' DLY'D TRIG.

DELAY PICKOFF

The Delay Pickoff circuit generates a positive-going differentiated pulse at a predetermined time during each sweep produced by Time Base A (Type 21A). The pulse is always available at the front-panel DELAYED TRIG OUT connector and is also applied internally to the delayed trigger amplifier in Time Base B (Type 22A) for use in the delayed sweep modes. Refer to the block diagram, Fig. 4-11, and to the Delay Pickoff schematic diagram during the following discussion.

Before the input sawtooth waveform has started its rise, V568A, V564 and V585B are conducting and V554 and V585A are cut off. V568B is conducting, but is biased near cutoff with the output voltage held near ground level.

Difference Amplifier

A sawtooth waveform from Time Base A is applied to the input of the Delay Pickoff difference amplifier, V554 and V564. This circuit is a comparator that compares the voltage level of the input sawtooth waveform against a voltage determined by the DELAYED TRIGGER 1-10 MULTIPLIER control. As the input sawtooth level exceeds the comparison voltage, the comparator produces an output waveform that is then applied to the delayed trigger multivibrator.

Quiescently, the common cathode voltage of the difference amplifier is set by the voltage on the grid of V564. This comparison voltage is adjusted by means of R573, the DELAYED TRIGGER 1-10 MULTIPLIER control. Total current through V554 and V564 is held constant by V568A, the constant-current tube. When the input sawtooth voltage reaches the level of the comparison voltage, the grid of V554 begins to control the voltage on the common cathodes, turning this tube on. As V554 turns on, the decreased current through V564 causes its plate voltage to start positive. As the sawtooth continues positive, the plate quickly reaches the switching level of the bistable delayed trigger multivibrator.

Because the input sawtooth waveform is the linear waveform from Time Base A, the time interval between the start of the Time Base A sweep and the instant of comparison is proportional to the voltage applied from the DELAYED TRIGGER 1-10 MULTIPLIER control. This control is accurately calibrated so that its readings correspond to the horizontal dis-

placement of the Time Base A crt beam on the screen at the time of comparison.

Constant Current Tube

V568A is a constant-current source for the difference amplifier. The voltage divider, R565 and R566, set the grid of V568A at about -50 volts. This stable grid voltage and the high resistance in the cathode force a constant current of 5 ma to flow through the tube. The two tubes of the difference amplifier share the current from V568A.

With current held constant through the conducting tube of the difference amplifier, regardless of the voltage levels being compared, the output signal of the difference amplifier will be uniform over the entire range of the 150-volt sawtooth waveform applied at the input grid.

Delayed Trigger Multivibrator

The delayed trigger multivibrator, V585A and V585B, produces a gate output that has a fast rise independent of the rate of rise of the input sawtooth.

When the voltage at the plate of V564 reaches the cathode voltage of the delayed trigger multivibrator, V585A begins to conduct. V585B cuts off as the multivibrator switches to its second bistable state. The resulting positive step at the plate of V585B is applied through a differentiating network to the grid of the delayed trigger output tube, V568B.

As the retrace portion of the input waveform occurs, the difference amplifier is switched back to its original state and the delayed trigger multivibrator is also switched back to the quiescent state. When it switches, the negative step at the plate of V585B is applied to the differentiating network.

Delayed Trigger C F

The positive-going portion of the differentiated waveform from the multivibrator applied to the grid of cathode follower tube, V568B, causes the tube to conduct more heavily. The 5-volt pulse appearing across R598 is thus obtained at low impedance at the cathode of the tube. This delayed trigger pulse is coupled to the DELAYED TRIG OUT connector on the front panel, and through the oscilloscope to the Time-Base Trigger circuit of Time Base B.

When the delayed trigger multivibrator resets and the negative pulse is applied to the grid of V568B, the tube is driven into cutoff and the output remains at ground. Thus the output waveform consists of only positive spikes.

The time delay between the start of the Time Base A sawtooth and the occurrence of the delayed trigger pulse is the delay time determined by the Time Base A TIME/CM switch and the 1-10 MULTIPLIER control. The Time Base A sweep will have moved across the crt screen the number of centimeters indicated by the MULTIPLIER dial.

HORIZONTAL AMPLIFIERS

The Horizontal Amplifier circuits for the Upper Beam and the Lower Beam are essentially identical. The following description applies to both circuits, but the circuit reference

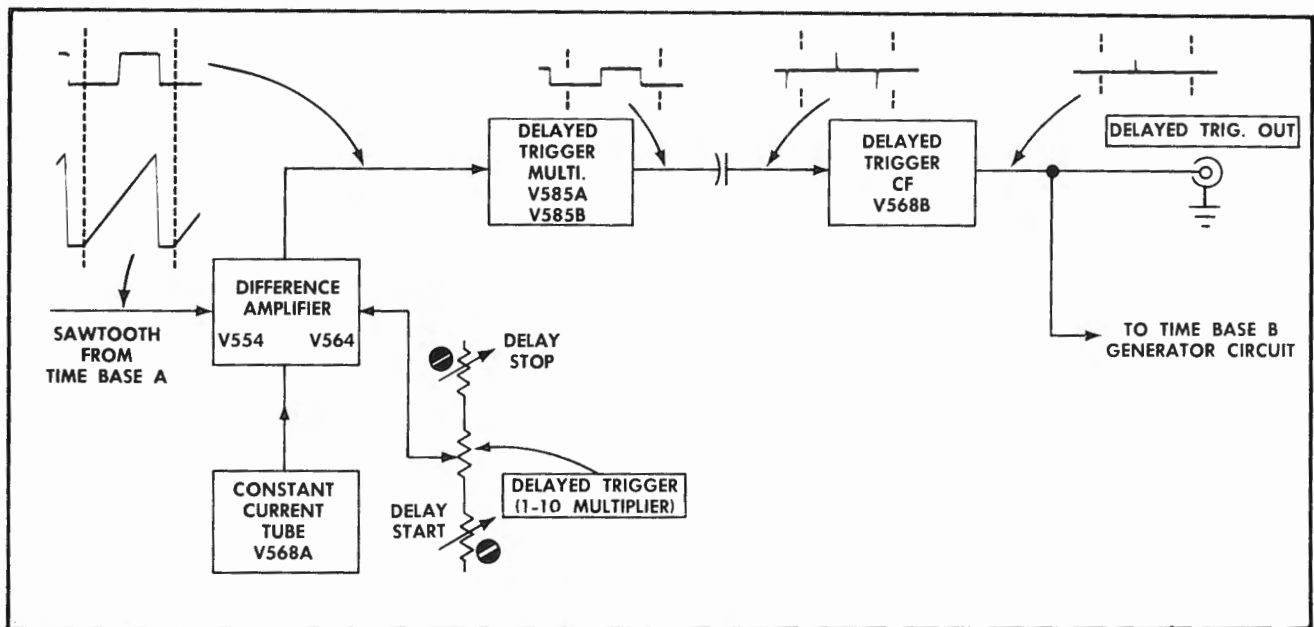


Fig. 4-11. Delay Pickoff block diagram.

numbers refer to the Upper Beam amplifier. Fig. 4-12 is a block diagram of the Upper Beam Horizontal Amplifier.

The input signal is selected with the appropriate HORIZ. DISPLAY switch from one of three sources: Time Base A sawtooth; Time Base B sawtooth, or the External Horizontal Amplifier for that beam. The input waveform is applied through an input cathode follower and a driver cathode follower to a cathode-coupled paraphase output amplifier. This amplifier provides a push-pull output to the horizontal deflection plates through a pair of output cathode followers.

Input Circuit

The input horizontal deflection voltage signal is applied through a frequency compensated voltage divider to the grid circuit of the input tube, V343A. Frequency compensation of the divider is adjusted with C330 during calibration. The two front-panel HORIZ. POSITION controls in the circuit provide horizontal positioning of the display by setting the dc level of the input signal. The two controls are operated by the same front-panel knob and are coupled by a "backlash" coupling that operates both the coarse adjustment, R333, and the fine adjustment, R336, simultaneously. Fine adjustment of the horizontal position is provided by R336 operating alone in a 60° arc permitted by the backlash coupling.

Driver and Output Stages

When the HORIZ. DISPLAY switch is in either of the X.2 positions or in one of the EXT. ATTEN positions, the signal from the input cathode follower is applied directly to the driver cathode follower in the left-hand deflection portion of the circuit. When the switch is in one of the X1 positions, the time-base signals are applied to the driver cathode follower through a compensated attenuator and are attenuated by a factor of 5. The attenuation is adjusted with the SWP CAL control, R351.

Gain of the Horizontal Amplifier is determined by the fixed feedback from the output of the amplifier through R355 and C355 to the input of the driver cathode follower, and by the setting of the MAG GAIN control, R372. Capacitor C372 is adjusted to maintain proper gain of the circuit at fast sweep rates.

The dc level at the grid of the driver cathode follower is adjusted with the SWP MAG REGIS control, R358, in the feedback loop to provide the same average dc level of the output signal whether the HORIZ. DISPLAY switch is in the X1 or the X.2 position. This insures that the center of the display will not shift when switching from an unmagnified to a magnified display.

The output cathode followers, V364B and V384B, provide the necessary low-impedance output to drive the capacitance of the horizontal deflection plates. "Bootstrap" capacitors C364 and C384, are adjusted for linearity of the fast rates.

Capacitance Driver

V398 in the cathode circuit of V364B controls the current through the left-hand cathode follower, and is designed to provide additional current boost at fast sweep rates, so the output waveform can remain linear while charging the capacitance of the circuit. The additional current is provided by applying a positive-going flat-topped pulse to the grid of V398 during the sweep. The pulse is obtained by differentiating the positive-going sawtooth from the right-hand portion of the circuit. The amplitude of the pulse is proportional to the slope of the sawtooth and thus to the sweep rate. A current boost is not provided for V384B since its current increase occurs during retrace when linearity is not so critical.

External Horizontal Amplifier

The External Horizontal Amplifier circuit shown on the Horizontal Display Switching diagram consists of a cathode-

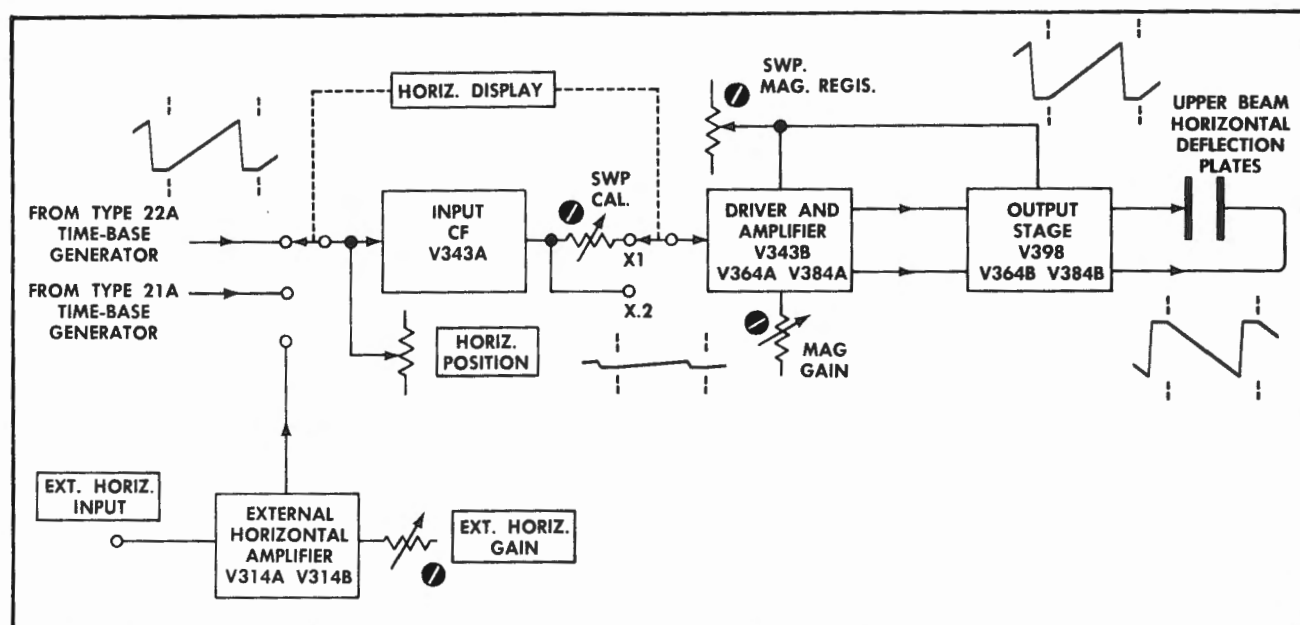


Fig. 4-12. Upper Beam Horizontal Amplifier block diagram.

coupled amplifier, V314A and V314B, providing horizontal deflection factors from 0.2 to 20 volts/cm. Input signals are applied through the HORIZ. DISPLAY switch to the grid of the input cathode follower, V314A. When the switch is at EXT. ATTN X10, the signal passes through a compensated attenuator where it is attenuated by a factor of 10. The amount of signal coupled to the cathode of the amplifier tube, V314B, is adjusted with the rear-panel EXT. HORIZ. GAIN control, R315, which has a 10-to-1 range. Quiescent current through V314B is adjusted with the EXT HORIZ AMP DC BAL control, R326, to match the current through V314A. With R326 properly adjusted, there is no dc current flow in R315 with no signal applied. If the external sweep signal has no dc component of its own, adjustment of the EXT. HORIZ. GAIN control will not move the position of the trace horizontally.

The amplified external horizontal signal may be connected through the HORIZ. DISPLAY switch to drive the Horizontal Amplifier circuit.

CRT CIRCUIT

The cathode-ray tube in the Type 555 has two sets of vertical deflection plates and two sets of horizontal deflection plates, operated independently of each other. The crt circuit consists of similar control circuits for the Upper Beam and the Lower Beam, plus a common high-voltage post acceleration circuit operated from the Lower Beam high-voltage transformer. Fig. 4-13 is a block diagram of the circuit. The crt requires an accelerating potential of about 10,000 volts. Approximately 1350 volts of this is supplied by the crt negative supply circuits and the remaining 8650 volts is provided by the post acceleration circuit.

High-Voltage Negative Supplies

The negative voltage supply circuit for each beam consists of an oscillator, a step-up transformer, a rectifier, a volt-

age regulator and an intensification circuit. The following description refers to the Upper Beam negative supply circuit, but applies as well to the Lower Beam.

The high-voltage oscillator is a modified Hartley circuit which operates at a frequency of about 60 kc, determined by the primary winding inductance of T801 and the capacitance in the circuit. Amplitude of the oscillator signal, and thus the amplitude of the rectified dc voltage, is adjusted by changing the voltage on the screen grid of V800. This voltage is controlled by the HV ADJ control, through the regulator circuit.

Transformer T801 steps up the oscillator signal to the required voltage, and V862 provides half-wave rectification to produce the -1350 volts. The negative dc high voltage is filtered by C844 and R844, then applied to the crt cathode and to a high-resistance voltage divider that includes the FOCUS control, R856, and the HV ADJ control, R852. When the HV ADJ control is properly adjusted, the voltage at the high voltage test point is -1350 volts. A portion of this voltage is fed back to the oscillator through the HV ADJ control for amplitude regulation. By comparing this voltage with the -150 volts at the cathode of V814B, any tendency of the rectified voltage to become more negative, for instance, would decrease current through V814B, causing the grid of V814A to become more positive. This in turn would increase current through V814A, lowering the screen voltage on V800, and thus would decrease the oscillator output amplitude to bring the rectifier output back to the correct value.

Post Acceleration Supply

A half-wave voltage doubler circuit, V932 and V942, rectifies the output from one secondary of the high-voltage transformer to provide the crt post-deflection anode potential of +8650 volts. Regulation of this voltage is provided through the transformer by regulation of the oscillator output.

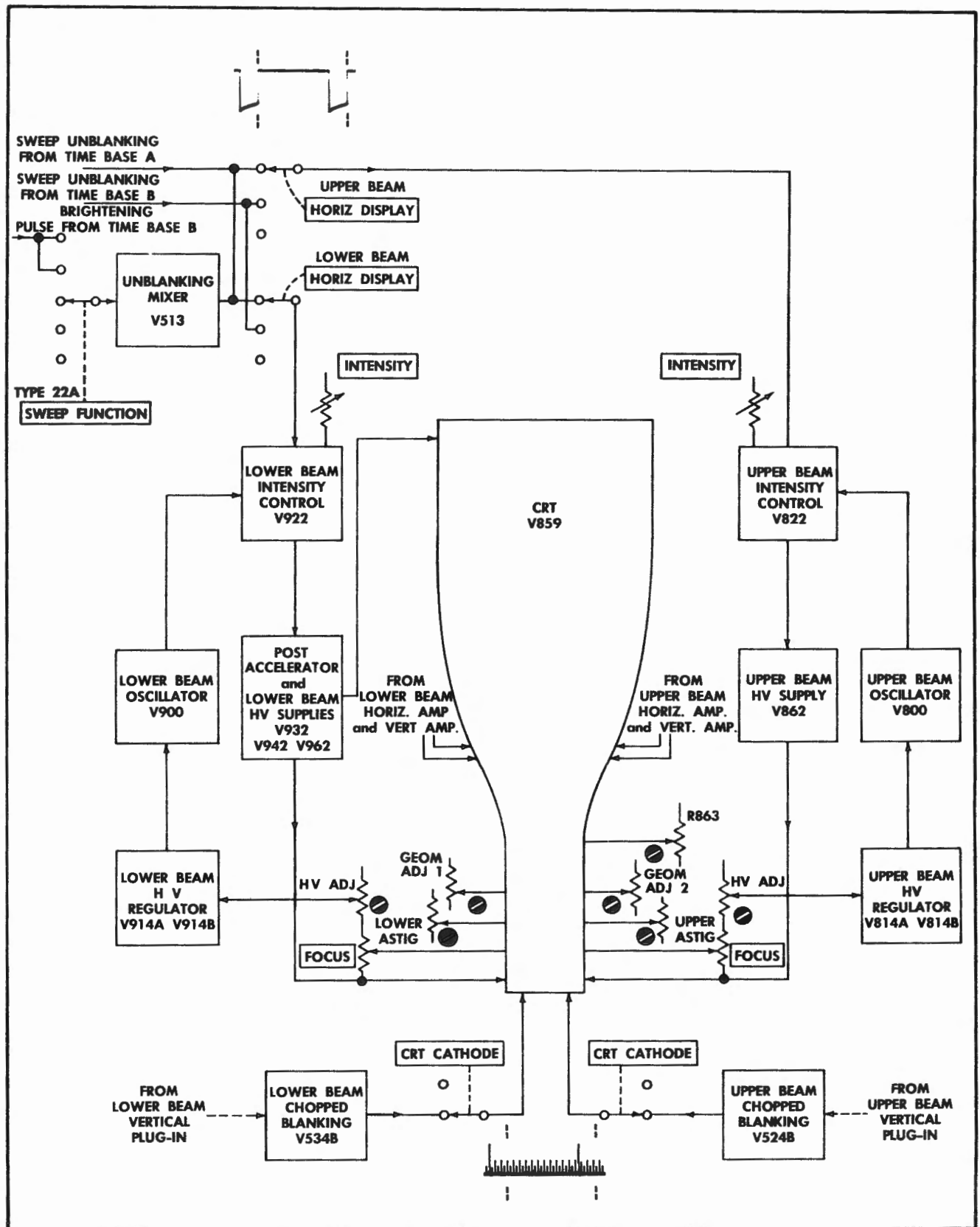


Fig. 4-13. Block diagram of Crt Circuit and intensification circuits.

Unblanking and Intensification

V822 rectifies the high voltage from another secondary winding of T801 to provide a bias supply for controlling the crt beam intensity. The front-panel INTENSITY control, R828, adjusts the negative voltage applied to the control grid of the crt, and thus the magnitude of the beam current. The range of the INTENSITY control varies the grid from about —1400 volts to —1320 volts. As the negative voltage is decreased, the beam intensity is increased. The sweep unblanking signal from the appropriate Time-Base Generator circuit is applied through R827, C827 and C828 in this circuit, modifying the voltage on the crt grid. Normally the INTENSITY control is set so the electron beam does not light the phosphor of the crt screen except during the positive portion of the sweep unblanking waveform. An intensifying signal is added to the intensity control circuit when using one of the delayed sweep modes. The signal is applied from Time Base B + gate circuit to the cathode follower unblanking mixer tube, V513, shown on the Horizontal Display Switching schematic diagram. The brightening signal then is coupled to either or both beams through the HORIZ. DISPLAY switch. Since the beam is already unblanked by the Time-Base unblanking signal, the positive brightening signal intensifies the beam driven by Time Base A for the duration of the Time Base B sweep.

Deflection Control Circuits

The FOCUS control, R856, varies the voltage on the focusing anode to adjust the focus of the beam at the crt screen. The UPPER ASTIG control, R863, adjusts the voltage on the astigmatism anode to vary the vertical focus of the beam with respect to the horizontal focus. The GEOM ADJ 2 control, R861, controls the field that the beam encounters as it emerges from the deflection system to control vertical display linearity. R863 (SHIELD VOLTAGE ADJ) controls the voltage applied to the isolation shield, and provides limited adjustment of the crt deflection sensitivity.

Blanking and Modulation

Ac-coupled blanking signals may be applied through switch SW848 to the crt cathode circuit either from the rear-panel CRT CATHODE connector or from the chopped blanking amplifier tube, V524B, shown on the Horizontal Display Switching schematic diagram. The waveform may thus be intensity-modulated to display additional information, such as time markers, or to delete unwanted portions of the display. Negative-going pulses intensify the beam and positive-going pulses tend to blank the beam. When no external signals are applied, the CRT CATHODE connector is grounded to eliminate random modulation of the beam.

To avoid displaying the vertical chopping signal when using a multi-trace vertical plug-in unit in chopped mode, the beam is blanked by a signal generated in the multi-trace unit. The chopped blanking pulses are connected to the oscilloscope through pin 16 of the vertical interconnecting socket, and applied to the grid of the chopped blanking amplifier tube, V524B, shown on the Horizontal Display Switching diagram (V534B is the amplifier for the Lower Beam). The signal is amplified and inverted, then applied through the CRT CATHODE switch to the crt cathode as shown on the Crt Circuit schematic diagram.

Beam Rotation

A trace-alignment coil surrounds the crt near the screen end of the tube to provide a few degrees of rotation of the entire display. The plane of the coil, L973 (on the Crt Circuit diagram), is parallel to the face of the crt. Dc current through the coil is adjusted with the BEAM ROTATION control, R973, to align the traces with the graticule lines.

When the instrument is moved to a new location, a change in the direction of the earth's magnetic field may affect the display alignment. If this occurs, the display can be realigned by a slight readjustment of the BEAM ROTATION control.

LOW-VOLTAGE POWER SUPPLIES

General

The low-voltage power supplies produce all operating voltages for the Type 555 Oscilloscope and its plug-in units, except for the high voltages in the crt circuit. The low voltage supplies produce regulated dc voltages of —150, +100, +225, +350 and +500 volts, an unregulated dc output of +330 volts, and a 6.3-volt unregulated ac filament supply. A separate circuit provides a regulated 6.3-volt ac rms filament supply.

All of the dc power-supply regulator circuits operate similarly. A sensing circuit compares a sample of the output voltage against a fixed reference voltage. Any difference between the output voltage and the reference then produces an error signal which is amplified and applied to the series regulator tubes, causing the regulators to correct for the error and return the output to the proper value. Fig. 4-14 is a block diagram of the —150-volt regulator circuit.

Reference voltage for the —150-volt supply is obtained from a gas-filled voltage-regulator tube. Reference voltages for the other dc regulated power supplies are obtained from the —150-volt output. Thus, the operation of all the positive dc regulated power supplies depends on that of the —150-volt supply. The outputs of all the regulated dc supplies are not separately adjustable. They are all changed when the —150-volt output is adjusted.

Power Transformers

Power for the dc supplies is provided by transformers T601 and T602 in the Power Supply Unit of the Type 555. Four full-wave bridge rectifiers are employed to rectify the transformer outputs for use in the dc supplies. In addition, T602 provides unregulated ac filament current for tubes in the Power Supply Unit.

Transformer T750 in the Indicator Unit of the oscilloscope operates with a saturable reactor, L790, to provide regulated ac filament current for most of the tubes in the instrument.

The primaries of each of the transformers have two windings that may be connected in parallel for 117-volt operation, or in series for 234-volt operation, as indicated on the schematic diagram of the Decoupling Network. Connections to the saturable reactor must also be changed to convert from 117-volt to 234-volt operation. All regulated supplies will remain in regulation over the line voltage range from 105 to 125 volts (or 210 to 250 volts) rms, at 50 to 60 cps line frequency.

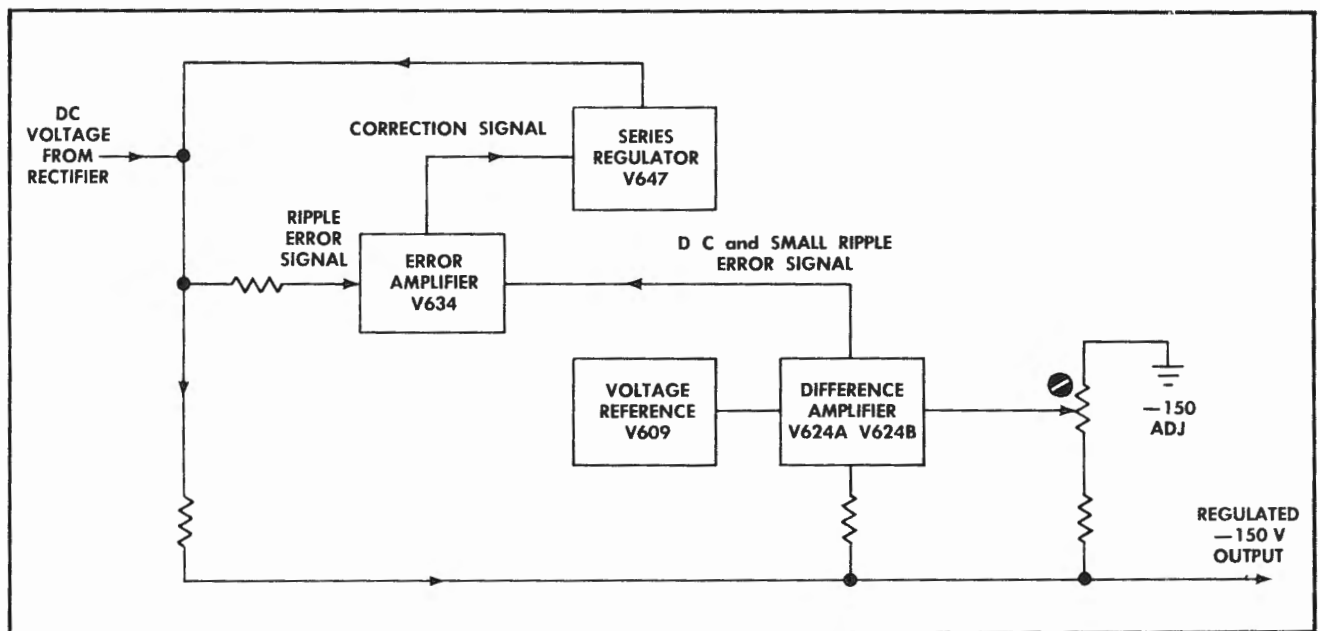


Fig. 4-14. Regulation circuit of -150-volt supply.

-150-Volt Supply

Reference voltage for the -150-volt supply is furnished by a gas diode voltage-reference tube, V609. This tube, which has a constant voltage drop, establishes a fixed potential of about -87 volts at one grid of difference amplifier V624. The voltage for the other grid of V624 is obtained from a divider consisting of R615, R616 and R617. The -150V ADJ control, R616, determines the percentage of voltage that appears at the second grid of V624 and thus sets the total voltage across the divider. This control is adjusted so that the output voltage is exactly -150 volts.

If the output voltage begins to change due to line-voltage or load fluctuations, the change will appear at the second grid of the difference amplifier, V624, producing an error signal at the output of the tube. Any error signal that exists will be amplified by V634, then applied to the grids of the series tube, V647. Since the voltage across V647 establishes the dc voltage level of the bridge rectifier, D642, any change in voltage across this tube caused by the correction signal on its grid will correct for the change in the -150-volt output and keep this voltage constant. C618 and C628 improve the ac response of the circuit to sudden changes in output voltage.

A small amount of ripple from the rectifier is applied to the screen of V634 through R637. The amplified ripple voltage at the plate of V634 is applied to the series regulator tube to cancel ripple on the -150-volt output lead.

+100-Volt Supply

Reference for the +100-volt supply is the -150-volt supply. The voltage divider R650-R651 compares the +100 volts and the -150 volts. Any voltage changes at the +100-volt output produce small changes at the grid of V664. The error signal is amplified and inverted by V664, then applied to the grid of the series regulator tube, V677, where it cor-

rects the output voltage on the cathode. Capacitor C650 increases the ac gain of the circuit for fast response to minimize ripple at the regulated output.

A small portion of the ripple on the supply lead from the rectifier circuit is connected to the screen of V664 through R667. This produces a ripple component at the grid of V677A that is in phase with the ripple at its plate, tending to cancel the ripple at the cathode and hence on the +100-volt output.

+225-Volt Supply

The voltage from terminals 11, 12-13 and 14 of T601 is rectified by diodes D702A and B and added to the voltage supplying the +100-volt regulator circuit, to furnish power for the +225-volt regulator. Reference for the +225-volt supply is the -150-volt supply. Any voltage change appearing on the +225-volt output lead produces a small change at one grid of V684. This voltage is compared to ground potential on the other grid of the tube, producing an error signal at the second plate of the tube (pin 1). The error signal is amplified and inverted by V694, then coupled to the grid of the series regulator tubes, V707 and V737A. The voltage change at the grids of the series regulator thus brings the output voltage at the cathode back to the correct value.

The unregulated output of about +330 volts is used only by the crt oscillator circuit and the regulated ac supply circuit. It is unnecessary to regulate this voltage, since these two circuits have their own regulators.

+350-Volt Supply

The voltage from terminals 11 and 14 of T601 is rectified by diodes D732A and B and added to the voltage supplying the +100-volt supply to furnish power for the +350-volt regulator. Reference for the +350-volt supply is the -150-volt supply. Any change on the output is applied to the grid

Circuit Description — Type 555/21A/22A

of V724 through the divider, R710-R711. Operation of the regulator circuit is essentially the same as that described for the +100-volt supply.

+500-Volt Supply

Voltage from terminals 20 and 21 of T601 is rectified by the full-wave bridge rectifier, D762A, B, C and D, and added to the regulated +350-volt output to supply the regulated +500-volt output. Reference for the +500-volt regulator circuit is the —150-volt supply. Any voltage change on the +500 volt output is applied to the grid of V754 through the voltage divider R740-R741. Operation of the regulator is essentially the same as that of the +100-volt supply.

Time Delay

The time-delay relay, K600, operates in conjunction with relay K601 to delay the application of power supply voltages to the oscilloscope tubes for about 45 seconds. This delay allows the tube cathodes to warm up before operating potentials are applied.

Heater Supplies

Two ac heater supplies provide power for the tube filaments. The 6.3-volt unregulated ac voltage from terminals 10 and 11 and from terminals 12 and 13 of T602 provide power for the filaments of several tubes in the Power Supply Unit. Transformer T750 provides power at a regulated 6.3 volts for all other tube filaments, including those of some tubes in the Power Supply Unit.

The regulator circuit for T750, shown on the Decoupling Network schematic diagram, is located in the Power Supply Unit and connected through the interconnecting cable to the transformer in the Indicator Unit. The circuit operates by regulating the voltage applied to the primary winding of the transformer. Any variation in the amplitude of the ac output from T750 appears across the secondary winding between terminals 11 and 12 of the transformer and is applied to the heater of the special diode tube, V799. The amplitude variation causes the diode to conduct more or less current, depending on the direction of the change, and produces a voltage change in the plate circuit of V799.

To illustrate operation of the circuit, assume the output voltage is slightly above the proper value of 6.3 volts. The current through V799 will increase slightly, causing the plate voltage to go in a negative direction. A portion of the negative-going voltage change is applied to the grid of V794, decreasing current through this tube and through the winding connected between terminals 5 and 6 of the saturable reactor, L790. A decrease in current through the winding increases the reactance of L790 to the line voltage, decreasing the amplitude of the ac voltage applied to the primary of T750. Thus the transformer output is brought back to the correct value. During calibration, the REG HTR ADJ control, R799, is adjusted so the output voltage is exactly 6.3 volts rms.

AMPLITUDE CALIBRATOR

The Amplitude Calibrator circuit provides an amplitude-calibrated square-wave output available in 18 steps at the front-panel CAL. OUT connector. The frequency of the square wave is about 1 kc and the duty factor is about 0.5.

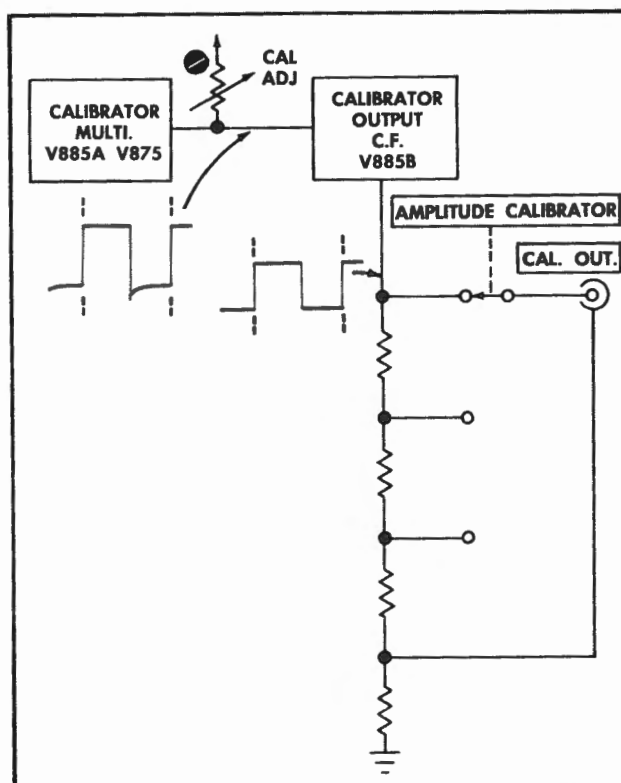


Fig. 4-15. Amplitude Calibrator block diagram.

The circuit consists of an astable plate-coupled multivibrator, V885A and V875, an output cathode follower, V885B, and a precision voltage divider in the cathode circuit of the output tube. Refer to the block diagram, Fig. 4-15, and to the Amplitude Calibrator Schematic diagram. The multivibrator switches the cathode follower alternately between conduction and cutoff, producing a 100-volt square wave at the cathode of V885B. The desired output amplitude is selected from the voltage divider by means of the front-panel AMPLITUDE CALIBRATOR switch.

The screen grid of V875 acts as the plate of a triode in the multivibrator section of the circuit. During the half cycle of the multivibrator action that V875 is conducting, part of the cathode current goes to the pentode plate and sets the plate voltage at about —35 volts. This voltage is applied to the grid of V885B, cutting the tube off and allowing its cathode to rest at zero volts.

When V875 is cut off by the multivibrator action, the voltage at its plate is set by the voltage divider, R879 (CAL ADJ) and R880. The plate voltage is adjusted during calibration with the CAL ADJ control so that when V875 is cut off, the output voltage at the cathode of V885B is exactly +100 volts.

The output voltage divider, R885 through R893, R896 and R897, divides down the +100 volts at the cathode of V885B. Square-wave amplitudes at the CAL. OUT connector, from .2 millivolts to 100 volts in 1, 2, 5 sequence, are selected from the divider with the AMPLITUDE CALIBRATOR switch, SW870. R899, a 0.25-ohm resistor between the output divider and ground, is provided to minimize stray pickup through the oscilloscope chassis.

SECTION 5

MAINTENANCE

PREVENTIVE MAINTENANCE

The Type 555 Oscilloscope system is a precision instrument and as such requires reasonable treatment and a certain amount of care. The instrument should be kept clean and should be serviced and recalibrated at regular intervals. If the Type 555 is given the minimum amount of care suggested in the following subsections, it should provide you with years of accurate and dependable service.

Periodic Inspection and Recalibration

The length of time between servicing will depend considerably on the amount of use the instrument receives, and also on the nature of its environment. We recommend servicing and recalibration after each 500-hour period of operation, or more frequently if the instrument is usually operated under adverse conditions such as a high temperature or a dusty or corrosive atmosphere. Even if the instrument is used only occasionally, it should be serviced and recalibrated at least once every six months. Servicing suggestions are given in this section of the manual; the calibration procedure is given in the Calibration section. Procedures for calibrating the vertical plug-in units are given in the instruction manuals accompanying the units.

Whenever the instrument is repaired or recalibrated, a visual check should be made of the controls and circuitry. Certain types of trouble can be detected by a visual inspection. Look for such obvious defects as control knobs out of alignment, damaged connectors, loose or broken solder connections, improperly seated tubes or transistors, broken terminal strips and scorched parts. Most of these troubles can be completely corrected by obvious means, except perhaps in the case of the heat-damaged parts. Quite often heat damage is the result of other less apparent trouble. In order to prevent further damage, it is essential that the cause of the overheating also be corrected before attempting to operate the instrument.

We strongly advise against routine replacement of electron tubes or transistors during periodic servicing. Since each tube or transistor has its own individual operating characteristics, any circuit that has one of these components replaced or exchanged will have to be recalibrated. If tubes or transistors are to be removed temporarily during servicing, they should be tagged with their circuit numbers to be sure they will be returned to their original sockets. Each circuit number is marked on the chassis next to the socket.

Removal of Panels

The side and bottom panels of each unit of the Type 555 Oscilloscope may be easily removed for access to the internal circuitry. The panels are held in place by small screw-head fasteners that can be released with a broad-blade screwdriver or a small coin. Turn each fastener about two turns counterclockwise to free the panel.

For normal operation, it is advisable to leave the side and bottom panels on the units to keep out dust and to provide adequate circulation of air from the fan. With the panels in place, all of the ventilating air must pass through the filters.

Cleaning the Exterior

A soft cloth dampened with water and a small amount of Kelite or Wisk can be used to remove dirt from the exterior of the Type 555. Abrasive cleansers should not be used. A dry paint brush is useful for dislodging dust that may be on or around the front-panel controls.

CAUTION

Do not clean any plastic materials with organic chemical solvents such as benzene, acetone or denatured alcohol. These solvents might damage the plastics.

The plastic faceplate of the crt may be cleaned with a soft lint-free cloth dampened in a water solution of soap or detergent. The faceplate and other plastic materials may also be cleaned with alcohols (e. g. isopropanol) that have not been denatured.

Cleaning the Interior

Although the air entering the oscilloscope is filtered, some dust may penetrate into the interior. This dust should be removed during periodic servicing of the instrument to prevent a heavy accumulation. Since some internal adjustments might be disturbed by the cleaning, it is suggested that the interior be cleaned before recalibration.

Probably the best way to clean the interior of the instrument is to blow off the dust with a low-velocity stream of compressed air. Avoid the use of a high-velocity air stream which might damage small components. Persistent dirt can be removed with a damp cloth or a small paint brush. A cotton-tipped applicator dampened with alcohol can be used for cleaning in narrow spaces and for cleaning ceramic strips.

Cleaning the Air Filter

The two units of the Type 555 Oscilloscope are cooled by air drawn through washable filters made of adhesive-coated aluminum wool. If a filter should become excessively dirty, it might restrict the flow of air and cause the unit to overheat; therefore the two filters should be checked every few weeks and cleaned when they appear dirty. Cleaning of the air filters should be done at least as often as the periodic servicing, and more frequently if the surrounding air tends to be dusty. High temperatures caused by the restriction of ventilating air can cause a general decrease in the life of tubes and other components.

If the temperature in either unit reaches 133°F, a thermal relay in the unit will turn off the oscilloscope. (After the temperature has dropped, the relay will automatically reset and restore power to the instrument.) Any time either thermal relay cuts out, check the air filter for excessive dirt or other restriction of air.

The following procedure is suggested for cleaning filters:

1. Flush loose dirt from the filter with a stream of hot water.

2. Place the filter in a hot-water solution of mild soap or detergent. Let it soak for a few minutes, then agitate the filter in the solution to wash out the dirt and old adhesive coating.
3. Rinse the filter in clear hot water, then allow it to dry thoroughly in the air.
4. Coat the filter with Filter Coat or Handi-Koater adhesive, available from the local representative of Research Products Corporation, or from an air-conditioning supplier. To prevent the adhesive from draining into the instrument, let the filter dry for several hours before putting it back into the unit.

Fan Motor Lubrication

The fan motor bushings in the Indicator Unit of the Type 555 should be lubricated during periodic servicing of the instrument (at least once every six months). Failure to lubricate the bushings may impair the operation of the fan and cause overheating of the unit or cause the motor to become noisy.

Two or three drops of light machine oil should be placed in each of the lubrication holes shown in Fig. 5-1. Do not over-lubricate the bushings—any excess oil will flow into other parts of the motor and will leak out into the oscilloscope. Oil on the outside of the motor or other exposed surfaces will tend to accumulate dust.

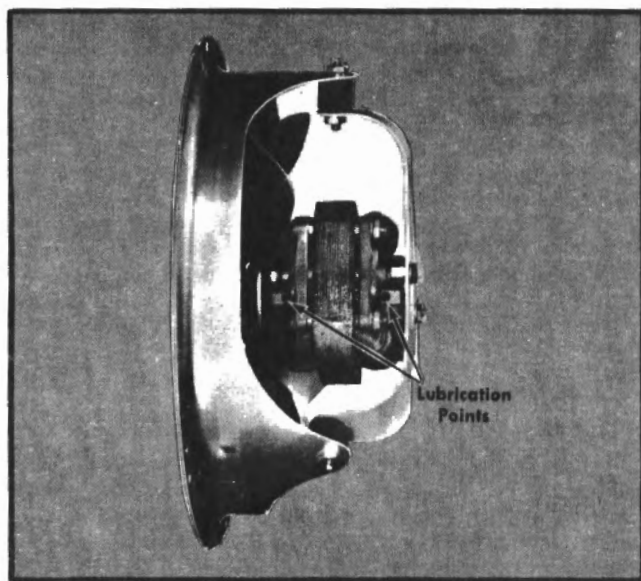


Fig. 5-1. Top left view of fan in Indicator Unit showing fan-motor lubrication points.

The fan motor bushings in the Power Supply Unit are factory sealed and will not require lubrication for the life of the instrument.

CORRECTIVE MAINTENANCE

The Type 555 Oscilloscope operates with the Type 21A and Type 22A Time-Base Units and the vertical plug-in units to produce the crt display. If apparent trouble develops in the system, first check the settings of all controls to make sure that some control is not disabling the system. Review

the Operating Instructions if you are not completely familiar with the operation of the instrument. If a signal is being applied, check the input cabling to make sure the signal is getting to the vertical input.

Then, if all front-panel control settings and input connections are correct for the desired mode of operation, but the instrument still does not operate properly, either there is trouble in the circuitry or some part of the system is out of calibration. Check the calibration of any suspected circuit before attempting to troubleshoot the instrument. A complete calibration procedure is given in the Calibration section of this manual; troubleshooting procedures and suggestions are given later in this section.

Ordering of Replacement Parts

If you have determined through operational or troubleshooting checks that an electrical or mechanical part requires replacement, use the following paragraphs as a guide for ordering the part.

Replacements for all parts used in the Type 555/21A/22A combination can be purchased directly through Tektronix at current net prices. Many of the electrical components can also be obtained from local electronics suppliers; however, certain critical electrical parts and most mechanical parts are selected or manufactured by or for Tektronix and should be ordered only from Tektronix since satisfactory replacement parts are not ordinarily available from other sources. Before ordering or purchasing any parts, be sure to consult the Parts List in this manual to determine the required characteristics.

When ordering a part through your local Tektronix Field Office, be sure to include the following information:

1. The complete description of the part as given in the Parts Lists;
2. The type of instrument (Type 555, Type 21A or Type 22A);
3. The Serial Number of your instrument.

Some parts may have been superseded by improved components since the production of your instrument. In such cases, the new part may be shipped instead of the part ordered.

Replacement Procedures

In general the replacement of most parts in the Type 555 Oscilloscope and its plug-in units is simple and straightforward. Just remove the defective part and install the replacement part. The following subsections contain some supplementary information about certain parts that require special care during replacement, as well as some practical hints to keep in mind while performing corrective maintenance on the instrument.

Soldering Considerations

In the production of Tektronix instruments, a silver-bearing solder is used to establish a bond with the ceramic terminal strips. This bond may be broken by the application of too much heat or by the repeated use of ordinary 40-60 tin-lead solder. However, occasional use of ordinary solder is permissible. For general repair work on Tektronix instruments,

solder containing about 3% silver should be used. Silver-bearing solder is available locally from electronics distributors, or may be purchased in 1 pound rolls through your Tektronix Field Office. Order by Tektronix part number 251-514.

Because of the shape of the terminal notches in the ceramic strips, it is advisable to use a wedge-shaped tip on your soldering iron when removing or installing parts. A wedge-shaped tip permits the application of heat directly to the solder in the terminals and reduces the amount of heat required. It is important to avoid excessive heating—a 50-watt iron is adequate. Do not use force or twist the tip of the soldering iron in the terminal notch, as this may chip or break the ceramic strip.

To solder or unsolder any small or short-lead component:

1. Use needle-nosed pliers to act as a heat shunt between the soldering point and the component;
2. Use a moderately hot iron for a short period of time;
3. Manipulate your tools with care to avoid damage to small components;
4. Use only enough solder to make a good bond.

Due to the presence of normal stray fields and capacitance within the instrument, the locations of some components in the Type 555 and its plug-in units are important to the operation of the system. Be sure to install replacement components in the exact positions occupied by the original parts.

After soldering any connection, clip off the excess length of the soldered leads. Be sure that these ends are not dropped into the instrument where they could cause electrical shorting.

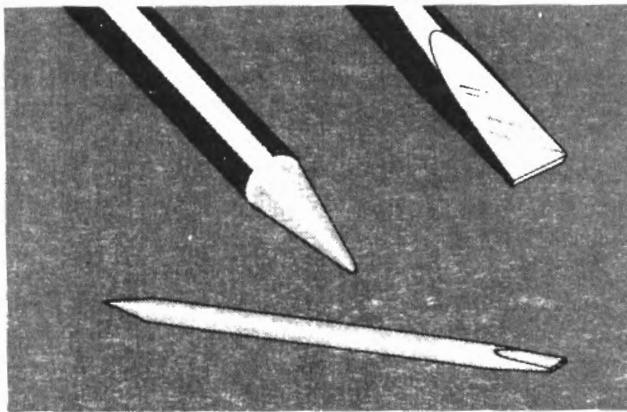


Fig. 5-2. Soldering aid for use with bare wires.

Fig. 5-2 illustrates a handy tool for holding bare wires in place while soldering. It can be made from a short length of wooden dowel or thermoset plastic, with one end shaped as a wedge.

When soldering to a wafer-type switch, do not let the solder flow around and beyond the rivet on the switch terminal. The spring tension of the switch contact may be destroyed by excess solder and the switch will need to be replaced.

Ceramic Strip Replacement

To replace a damaged ceramic terminal strip, first unsolder all connections, then pry the mounting studs, attached to the strip, out of the chassis. If prying is not satisfactory, remove the studs by tapping on the ends protruding from the reverse side of the chassis. Still another way to remove a ceramic strip is to use diagonal cutters and cut off one side of each stud. The remainder of the studs can then be pulled out after the strip has been removed.

If the nylon spacers do not come out with the studs, they may be left in the chassis or pulled out separately. The spacers, if not damaged, can be used with the new ceramic strip assembly. Replacement strips are supplied with mounting studs attached, so it is not necessary to salvage the old studs.

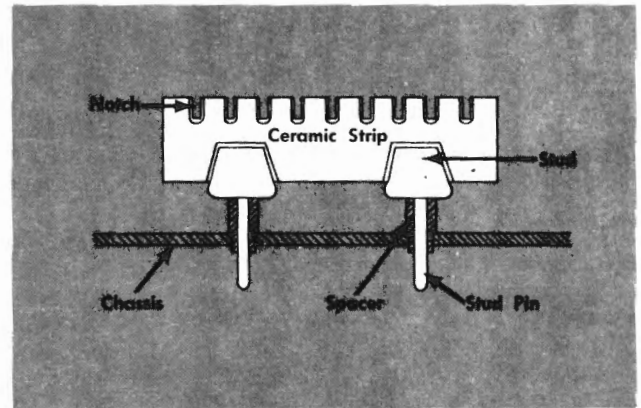


Fig. 5-3. The assembled ceramic strip.

When the damaged strip and stud assembly have been removed, place the spacers into the mounting holes in the chassis and press the mounting studs of the new strip assembly into the spacers. It may be necessary to tap lightly or apply some pressure to the ceramic strip to make the studs seat all the way down into the spacers. To avoid damage to the terminal strip use a soft-tipped tool for tapping, and apply force only to the parts of the strip directly above the mounting studs. Fig. 5-3 shows the assembled terminal strip. Cut off the excess length of the mounting studs extending beyond the ends of the spacers. Resolder all components and wires in place as they were previously arranged (note the soldering considerations given above).

Power Transformer Replacement

If a complete check of the instrument shows that one of the power transformers requires replacement, notify the closest Tektronix Field Office. It may be necessary to have a Tektronix Field Engineer verify the transformer failure for a warranty replacement of the transformer (see the Warranty note in the front of this manual).

Be sure to use only the correct replacement for a power transformer. As the leads are unsoldered from the transformer being removed, it may be advisable to tag the leads with the terminal numbers. After the replacement of a power transformer a complete recalibration of the oscilloscope will be required.

Replacement of Rotary Switches

Only a normal amount of care is required for the removal of a defective switch. When a switch is removed the leads should be labeled as they are detached to assure that the new switch will be connected properly. If one section of a rotary switch is defective, the entire switch should be replaced. Sections are not normally replaced separately. Some switches may be ordered from Tektronix with or without the associated components wired in place. Check the Parts List for the appropriate part numbers.

Crt Replacement

To remove the cathode-ray tube, first remove the side panels and the time-base units from the Indicator Unit. Disconnect the socket from the base of the crt, and the lead clips from the deflection plate pins at the neck of the crt. Be careful not to bend the neck pins. (Do not disconnect the high-voltage anode connector or the beam-rotation coil leads at the top of the crt shield near the front of the instrument). Remove the graticule cover, the scratch shield (or light filter), the "eyebrow" light pipe and the light-pipe hold-down spring. Loosen the clamp at the neck of the crt and carefully push the tube forward until it can be removed from the front of the instrument.*

Insert the new crt with the high-voltage anode contact pointing directly upward so it will touch the brush contact inside the crt shield. Temporarily replace the scratch shield and graticule cover, then screw down the knurled retaining nuts. Position the crt so the graticule lines are parallel to the sides of the oscilloscope and crt faceplate is touching the scratch shield. Tighten the neck clamp.

After the crt is securely in place, connect the base socket and neck clips. The color-code information on the crt shield indicates the order in which the neck-pin leads are to be connected. Remove the graticule cover and scratch shield, install the "eyebrow" and its hold-down spring, then replace the scratch shield and graticule cover.

After replacement of the crt, it will be necessary to calibrate the crt circuit and check the calibration of the rest of the instrument. Adjust the BEAM ROTATION control before beginning the calibration procedure.

Recalibration After Repair

After the replacement of any electrical component, it will be necessary to check the calibration of the circuit involved. If other circuits are closely related, as seen on the schematic diagrams, their calibration should also be checked. Since the low-voltage supplies affect all circuits, the entire instrument will need recalibration if work has been done in the low-voltage supplies or if one of the power transformers has been replaced.

TROUBLESHOOTING

This portion of the Maintenance section contains information intended to aid in locating and correcting any apparent troubles that may occur in the system. Suggestions are given

*For an instrument with an external graticule crt (instrument S/N's 7000-8999), the procedure is essentially the same as that described, except for the references to the "eyebrow" light pipe, etc. When installing a new crt of this type, position it so the brush contact inside the crt shield touches the crt anode contact, and the face of the crt is touching the external graticule.

for isolating the trouble to a particular circuit, and for component checking and circuit tracing after the general location of the trouble is known.

The Type 555 Oscilloscope incorporates several features in its design that will simplify the isolation of trouble. The most significant of these features is the built-in versatility of the instrument which incorporates two completely independent vertical and horizontal deflection systems (with the exception of the low-voltage and crt circuits). The time-base circuits and the vertical input circuits are mounted in plug-in units that can be quickly replaced or extended to facilitate isolation and troubleshooting. In addition, the time-base units can be switched by front-panel controls so that either beam can be operated by either time-base generator.

The system can usually be used to check itself for the isolation of trouble to a particular circuit. If one beam is operating properly, it can be used for the detailed checking of a defective circuit.

Several of the circuits in the Indicator Unit of the oscilloscope are essentially independent from the rest of the system. These circuits are:

1. Amplitude Calibrator
2. Upper Beam External Horizontal Amplifier
3. Lower Beam External Horizontal Amplifier
4. Delay Pickoff
5. Unblanking Mixer
6. Upper Beam Chopped Blanking Amplifier
7. Lower Beam Chopped Blanking Amplifier
8. Beam-Rotation Circuit

If the oscilloscope operates normally except when set for a mode utilizing one of these independent circuits, the trouble is probably located in the particular circuit involved. For example, if the system operates properly in all modes except SWEEPS ONCE FOR EACH 'A' DLY'D TRIG or TRIGGERABLE ONCE FOR EACH 'A' DLY'D TRIG, it can be assumed that the trouble is associated with either the Delay Pickoff or Unblanking Mixer in the Indicator Unit, or the Delayed Trigger Amplifier or Lockout Multivibrator in the Type 22A. (See the Block Diagram at the beginning of the Schematic Diagram section for the interrelation of the various circuits.)

Familiarity with the normal operation of the instrument is of great assistance in locating trouble. This familiarity can be gained through the use of this manual, as well as through actual use of the instrument. After isolating the trouble to a particular circuit by operational checks, you will probably find it helpful to refer to the Circuit Description and schematic diagrams while checking out the circuit in detail.

Troubleshooting Procedure

In general, the following steps will provide an efficient troubleshooting procedure for this instrument:

1. Isolate the trouble to a particular unit of the system, then to a particular circuit.
2. Check the tubes and transistors in the suspected circuit.
3. Check the calibration of the circuits (as much as possible) according to the procedure given in the Calibration section.

4. Troubleshoot the circuit if the trouble was not a tube or transistor, or could not be corrected by recalibration.
5. Repair and readjust the defective circuit.

Sometimes the source of a trouble will be obvious from the symptoms present at the time the difficulty was first noticed. At other times it will be necessary to perform some operational checks to isolate the trouble to a particular circuit. The isolation procedure included here is for locating trouble when the source is not immediately apparent from the operation of the instrument. However, no attempt is made here to trace the malfunction to a particular component or group of components. When the general location of the trouble is known, the circuit can be checked by the procedure outlined above.

Do not overlook the possibility that some symptoms may indicate troubles other than those that are most obvious. For example, if the timing or sensitivity are incorrect, the trouble may appear to be located in one of the plug-in units. However, these problems can also result from trouble in the low-voltage or crt circuits. Further operational checks will usually clear up any doubts as to the true location of the source of trouble.

Circuit Isolation

If trouble appears in the operation of the system, attempt to isolate the source quickly through the operation of front-panel controls. Many apparent troubles are caused by the improper setting of one or more controls, or by improper calibration of some portion of the instrument.

First check the settings of all controls to make sure they are correct for the desired mode of operation. Next operate each control to see what effect, if any, it has on the symptoms. The normal or abnormal operation of the controls may help locate the source of trouble.

Check Voltage Supplies

If the nature of the trouble is such that its source cannot be located by operating the front-panel controls individually, the trouble may be caused by either the low-voltage supplies or the high-voltage and crt circuit. These circuits, which are utilized in common by both beams, must be operating correctly to present the proper display on the crt screen.

Check for the correct voltages at the two —1350 TEST POINT locations and at the low-voltage test points indicated in the calibration procedure. The low-voltage supplies should be checked for ripple and regulation as well as for output voltages.

CAUTION

Do not adjust the —150 ADJ control or either of the H V ADJ controls unless the voltage is actually out of tolerance. Any adjustment of the —150 ADJ control will necessitate recalibration of the entire instrument. Adjustment of one of the H V ADJ controls will require complete recalibration of the beam associated with that control.

If the trouble is found to be in one of these circuits, keep in mind that replacement of any parts will necessitate recalibration of the instrument.

If the low-voltage supplies are out of regulation with high output voltages, the condition may be the result of incorrect loading due to failure of other circuits in the system.

If the low-voltage supplies are operating correctly and the voltage at each —1350 TEST POINT is correct, check the high-voltage oscillators (V800-V814 and V900-V914) for proper operation. Refer to the Crt Circuit schematic diagram.

Check Horizontal and Vertical Systems

If the voltage supplies appear to be operating correctly, check the operation of the system under the following conditions.

With no input signal applied, set the front-panel controls as indicated:

Upper Beam

HORIZ. DISPLAY	TIME BASE A X1
FOCUS	Centered
INTENSITY	Counterclockwise

Lower Beam

HORIZ. DISPLAY	TIME BASE B X1
FOCUS	Centered
INTENSITY	Counterclockwise

Time Base A and Time Base B

TIME/CM	50 mSEC
SWEEP FUNCTION	AUTO BASELINE
VERNIER	Centered
LEVEL	Clockwise
SLOPE	+
COUPLING	AC
Time Base A SOURCE	UPPER BEAM
Time Base B SOURCE	LOWER BEAM

Vertical Input Units

Deflection Factor	1 v/cm (cal.)
Input Coupling	AC

Using the beam-position indicator neons as a guide, attempt to center the two beams on the crt screen with the HORIZ. POSITION and Vertical Position controls. Cautiously turn the INTENSITY control of each beam clockwise to display a trace or spot of normal intensity. (If no trace or spot appears on the screen, turn the INTENSITY control back to the counterclockwise position).

With the controls set as indicated, both beams should be free running at a rate that causes the two horizontal beam-positioning neons to light and go out alternately when the trace is approximately centered. Both vertical-position indicator neons should be unlit when the trace is centered vertically.

If the traces can be centered but have incorrect intensity, check the crt circuit voltages in detail. Note that the Lower Beam crt circuit supplies the post-accelerating potential for both beams. Do not connect a standard probe to any of the high-voltage portions of the crt circuit, since the accelerating voltages on the crt far exceed the capability of the probe and oscilloscope input.

If either of the traces cannot be centered, there is probably an unbalanced condition in the horizontal or vertical system of that beam. The beam-indicator neons will usually indicate which direction the beam is off the screen, and thus will tell whether the trouble is in the horizontal or vertical circuitry.

If neither beam is operating normally, the indication is that there is trouble in one of the voltage supplies or in the crt circuit. (It is improbable that both horizontal systems or both vertical systems would fail without a power or crt circuit failure.) Since the supply voltages and high-voltage oscillator have already been checked, proceed to check out the crt circuit in detail.

If no trouble is found in the crt circuit, check the balance of the horizontal and vertical amplifiers as given below, even though the beam-position indicator neons may have shown the amplifiers to be balanced.

Check Time-Base Plug-Ins

If the beam-indicator neons show that the time-base generator is not running (beam lights not alternating), the trouble is probably in the time-base plug-in unit. However, if the beam is indicated to be off the screen horizontally in either direction, the trouble may be caused by either the time-base plug-in unit or the horizontal deflection system in the Indicator Unit.

Check the time-base plug-in units by reversing the settings of both HORIZ. DISPLAY switches or by substituting other

time-base units for those presently being used. (If Types 21 and 22 are substituted for the Types 21A and 22A, see the compatibility note in the Operating Instructions section.)

^{see p. 12-6}
If the trouble was switched to the other beam by operation of the HORIZ. DISPLAY switches (or eliminated by substitution), the time-base unit was causing the difficulty. If not, check for unbalance in the Indicator Unit as described below.

Check Vertical Plug-Ins

If the beam indicators show the beam to be off the screen vertically, the indication is that the vertical deflection system is unbalanced. This could be due to either the vertical input plug-in unit or to the vertical amplifier or crt in the Indicator Unit.

To check the vertical plug-in units, either interchange the units in the Upper Beam and Lower Beam plug-in compartments or substitute other vertical plug-in units known to be in operating condition.

If interchanging the plug-in units switched the trouble to the opposite beam, the source of trouble is in the plug-in unit. If this is the case, check the plug-in unit according to the procedure given in the manual accompanying the unit. However, if the trouble was not affected by substituting another plug-in unit, the unbalance is in the Indicator Unit of the oscilloscope. Check for the unbalance as described in the following paragraphs.

Check Unbalance

If the isolation checks indicate vertical or horizontal unbalance in the Indicator Unit, locate the source of the unbalance by shorting across between the two sides of the circuit. Use a shorting strap such as the one illustrated in Fig. 5-4.

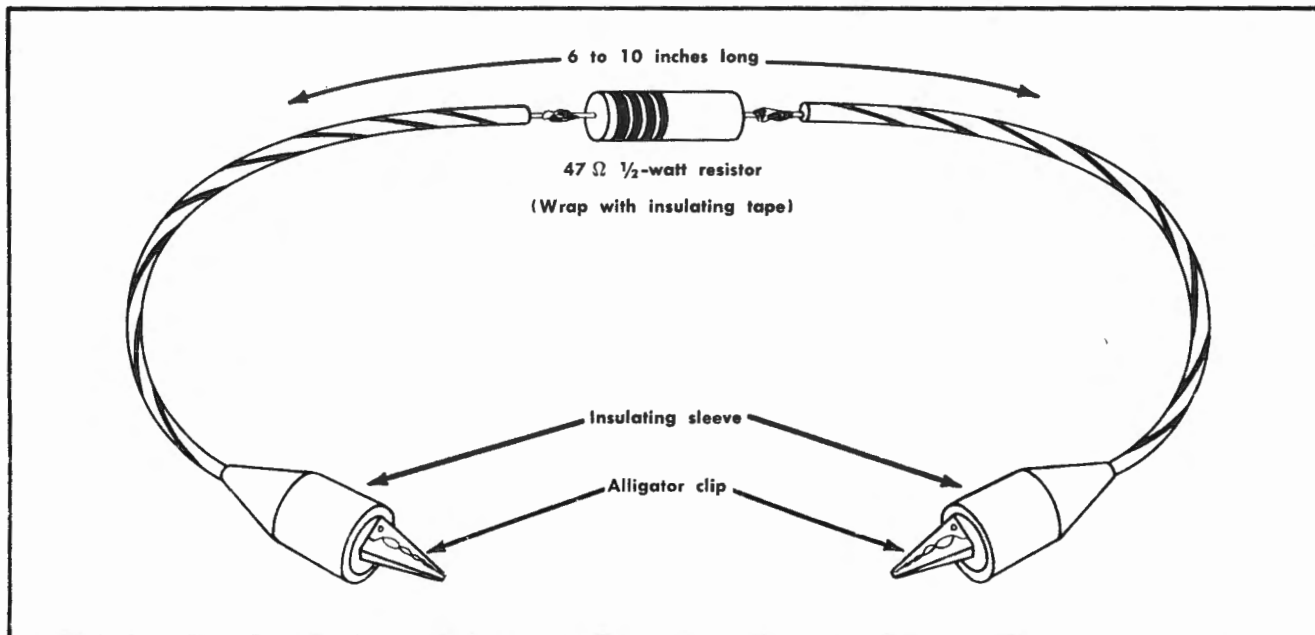


Fig. 5-4. Shorting strap for checking vertical or horizontal unbalance.

Begin the unbalance check of the particular vertical or horizontal circuit by shorting between the two leads connected to the deflection-plate neck pins on the crt. (When checking the horizontal balance, adjust the Vertical Position control to center the spot.)

CAUTION

While connecting the shorting strap, have the INTENSITY control turned fully counterclockwise, then increase the intensity to normal.

If the crt beam did not produce a spot or trace on the screen when the intensity was increased, either the crt is defective or the beam-control circuits are not functioning properly.

If the spot or trace appeared on the crt screen, leave the INTENSITY control set for normal brightness and begin working back toward the input of the vertical or horizontal amplifier. Short the two input grids together at each stage of the amplifier. When you reach the point where a spot or trace does not appear as the short is connected, the unbalanced condition is in the stage immediately following the short.

Visually inspect the components in the unbalanced stage. Check the tubes by substitution. Replace defective tubes if necessary and recalibrate the circuit. If the trouble is in the

distributed amplifier section of the vertical amplifier, the replacement tubes should be a balanced pair.

Circuit Troubleshooting

When the trouble has been isolated to a particular circuit, perform a complete visual check of the circuit. For checking the circuitry the side and bottom panels of both units of the oscilloscope can be removed, and the time-base units can be extended with the extensions provided. See Figs. 5-5 through 5-7 for the locations of the various circuits. (For troubleshooting the vertical input plug-in units, refer to the instruction manuals of the particular instruments.)

If a visual check of the circuit fails to detect the cause of the trouble, check the tubes and transistors as described below, and check the calibration of the circuit as much as possible under the circumstances. Most circuit failures are caused by electron tube or semiconductor failure due to normal use and aging. Another cause is component failure resulting from careless operational or servicing procedures. Be careful when checking inside the instrument with meter leads or probe tips. Careless shorting of leads can apply abnormal voltages of transients to the components and cause the destruction of semiconductors and other small components.

If the trouble was not found to be a tube or semiconductor, and the source of trouble was not located by a cali-

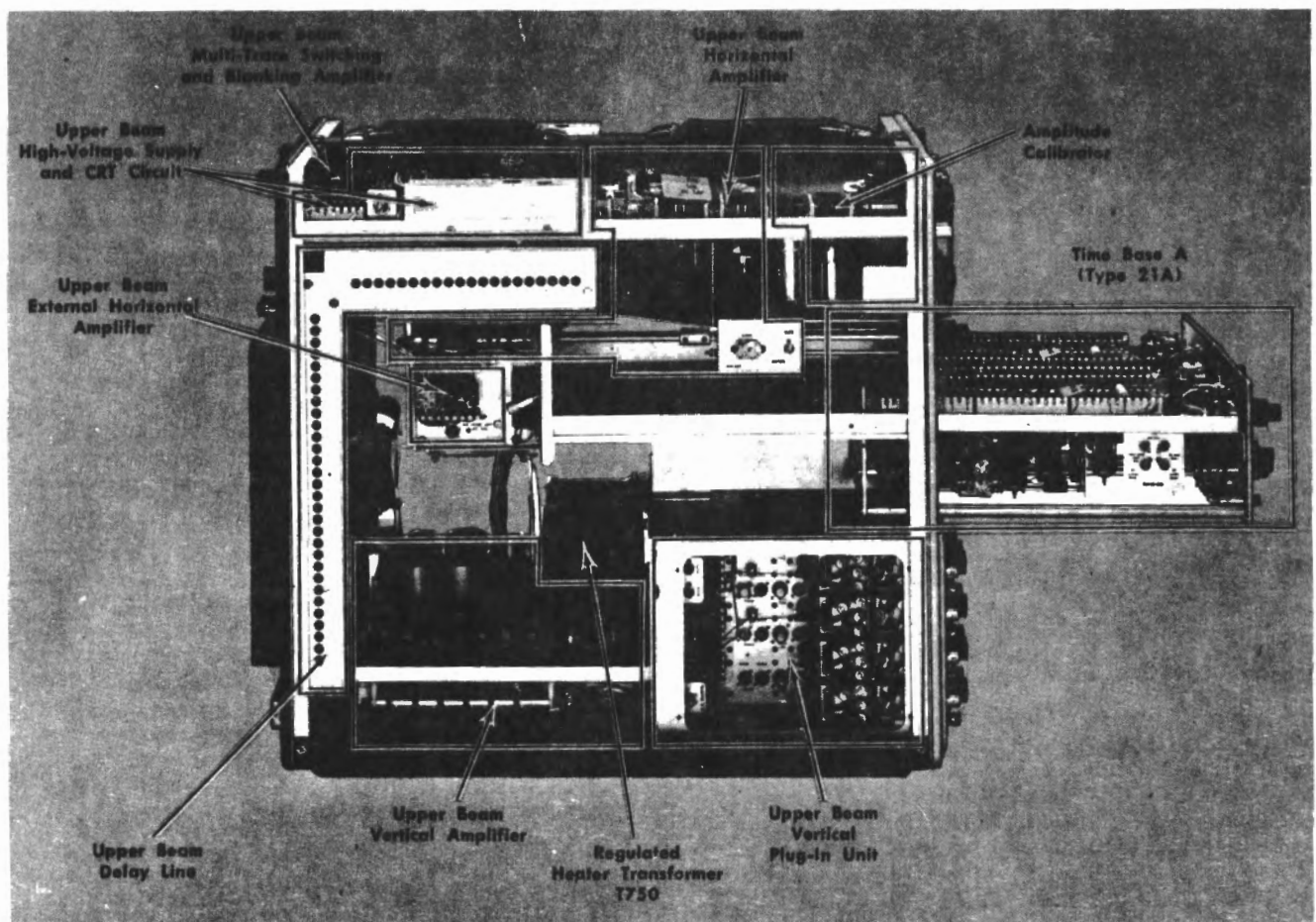


Fig. 5-5. Left side view of Indicator Unit with Time-Base Units extended.

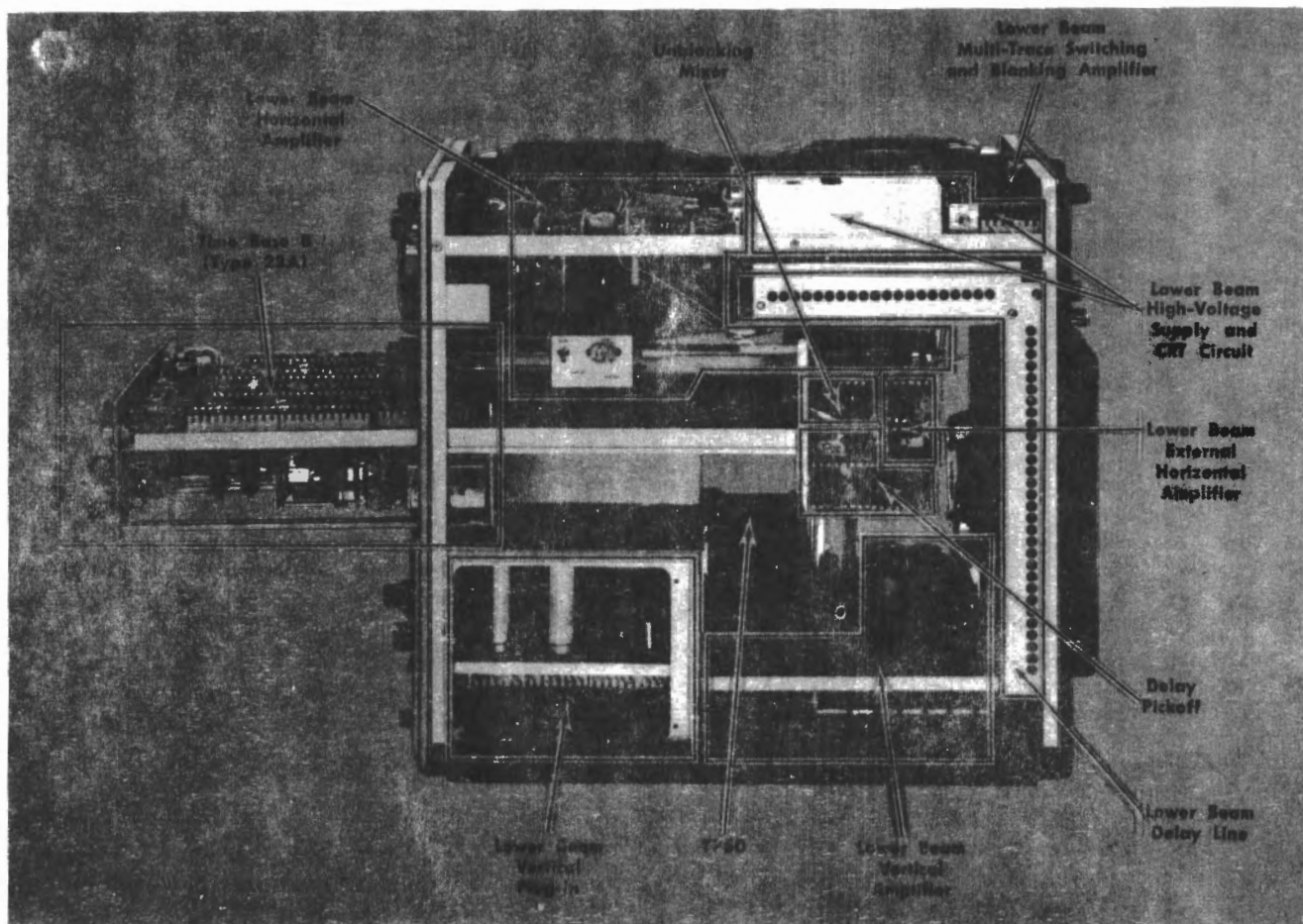


Fig. 5-6. Right side view of Indicator Unit with Time-Base Units extended.

bration check of the circuit, use a test oscilloscope and a high-impedance voltmeter to check the circuit out in detail (see the section on troubleshooting aids below). If one beam of the Type 555 is operating correctly, it can be used as the test oscilloscope.

When checking a circuit that utilizes an input signal, it may help to apply a known external signal that is appropriate for the particular circuit, and trace the signal through the circuit. For a circuit that has an identical counterpart in the other beam, it may also be helpful to apply identical signals to the two circuits and compare the results through the circuitry.

Troubleshooting Aids

Schematic diagrams of the circuits of the Type 555 Oscilloscope and the Types 21A and 22A Time-Base Units are contained in the rear of this manual. The circuit number of each component, as well as important voltages and waveforms, are shown on the diagrams. Be sure to note the conditions under which the voltages and waveforms were obtained. The range of circuit numbers used on a particular diagram is given on that diagram.

In the instrument, the circuit number of each tube, transistor, electrolytic capacitor and internal control is marked

on the chassis near the component. These numbers provide convenient reference to the components indicated on the schematic diagrams.

Rotary switches shown on the schematics are coded to indicate the physical positions of the switch contacts. The sections of a switch are numbered from the front-panel to the rear of the assembly. The letters F and R indicate whether the front or the rear of the section is used to perform the particular switching function. For example, the designation 3R means the rear side of the third section.

All wiring in the instrument is color-coded. For the purpose of circuit tracing, nearly every signal lead carries one or two colored stripes. Each voltage-supply lead is coded with two or more stripes that indicate the approximate voltage carried by the lead. The standard EIA code is used on the power leads, with the stripes being read in order of decreasing width.

Checking Tubes and Transistors

Commercial testers are not recommended for checking the tubes and transistors used in the Type 555. Tube testers often fail to indicate defects that affect circuit performance, or indicate a tube to be defective when it is operating satisfactorily in the circuit. The same applies to similar tests

made on transistors. The best criterion for determining whether a component is good or bad is its operation within the circuit. If a tube or transistor is operating properly it should not be replaced. Unnecessary replacement or switching of components may require that the instrument be needlessly recalibrated.

Direct substitution is usually the best means of checking a tube or transistor. A characteristic curve display instrument, such as a Tektronix Type 570 or Type 575, may also be useful in checking a tube or transistor that is suspected of being defective. Be sure to return all tubes and transistors to their original sockets if they are found to be good.

Often a transistor or diode can be checked for an open or shorted condition merely by making an ohmmeter check between terminals. Use a resistance scale with a $1\frac{1}{2}$ -volt internal source and measure the dc resistance between two terminals of the semiconductor, first in one direction then the other, and note the effect of polarity reversal.

CAUTION

The use of a high source voltage for the meter may exceed the breakdown voltage of the junction. This will give an erroneous reading, and may destroy the semiconductor being checked.

Before installing a replacement tube or transistor, be sure that the circuit voltages are approximately normal. If re-

placement is made without checking the circuit, the new component may be damaged by some defect in the circuit.

For replacing the cathode-ray tube refer to the CRT Replacement procedure given previously under Corrective Maintenance.

Component Checking

Components that are soldered in place can usually be checked quickly after unsoldering one end. For example, a junction diode can be checked with an ohmmeter by measuring the resistance through it in each direction. With an ohmmeter scale using an internal source of $1\frac{1}{2}$ volts, the resistance should measure very high in one direction and very low in the other.

A capacitor can be checked for a leaky or shorted condition by checking its resistance on a megohm scale. The resistance should read infinite as soon as the capacitor is charged. An open capacitor may best be detected with a capacitance meter or by checking the waveform on each side of the component with the circuit in operation.

An open condition in a resistor or inductor can be detected by an ohmmeter continuity check. Shorted or partially shorted inductors can usually be found by analysis of high-frequency signals passing through the circuit. Partial shorting reduces the frequency response (rolloff).

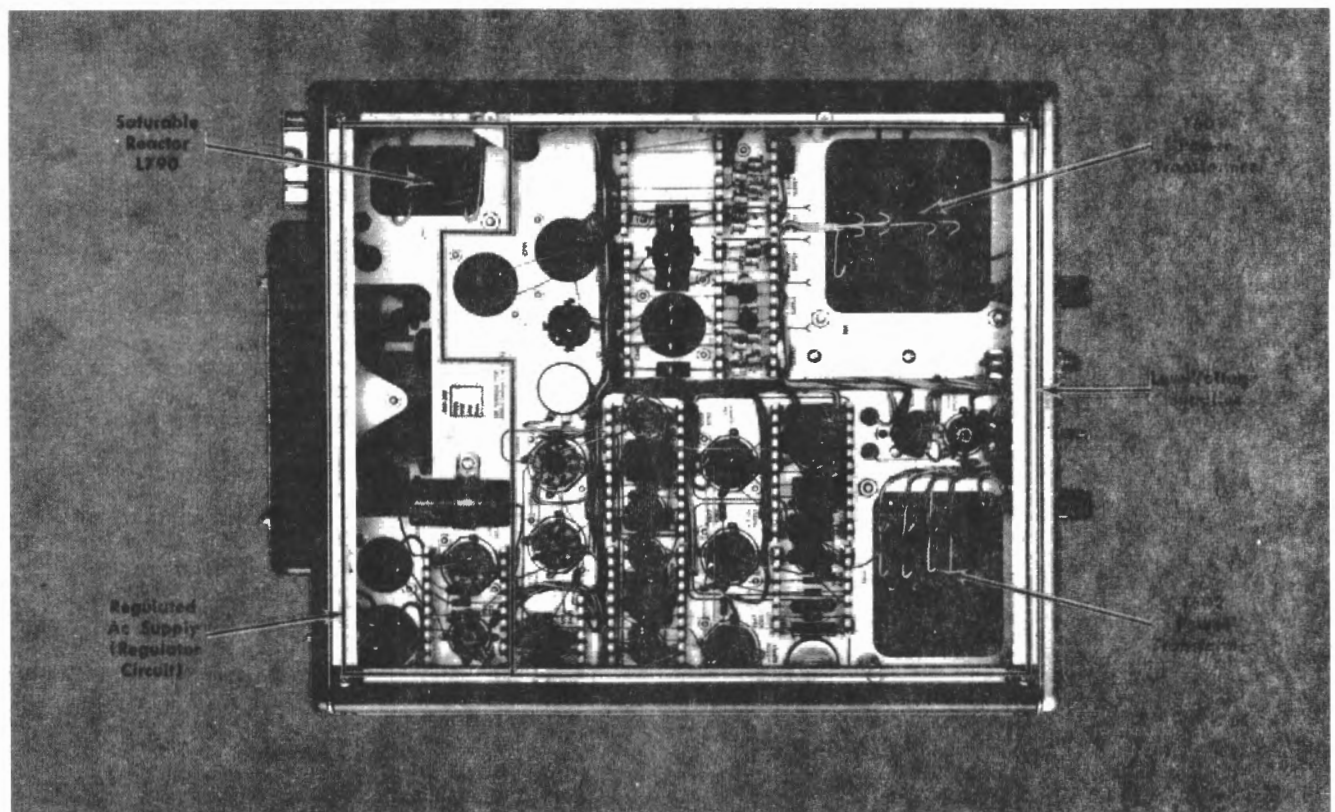


Fig. 5-7. Bottom view of Power Supply Unit.

NOTES

SECTION 6

CALIBRATION

GENERAL INFORMATION

The Type 555 Oscilloscope is a stable instrument and does not require frequent recalibration; however, its calibration should be checked at regular intervals to insure that it is operating properly and accurately. (See the Maintenance section of this manual for the recommended recalibration interval.) In addition, certain portions of the instrument must be recalibrated after tubes have been changed or repairs have been made. A complete procedure is provided in this section for checking the calibration of the Type 555 and its time-base plug-in units, and for making adjustments when necessary.

In the instructions that follow, the steps are arranged in convenient sequence to avoid unnecessary repetition. If a complete recalibration is not necessary, individual steps may be performed separately if those steps do not affect any other adjustments. It is important for you to be aware of the interaction of the adjustments. In general, this is apparent on the schematic diagrams, but if you are in doubt, check the calibration of all closely associated circuits.

If adjustments are made on the power supplies, the calibration of the entire instrument will have to be checked. In particular, the sweep rates and vertical deflection factors will be affected.

Control settings are given every few steps. Any controls that are not mentioned are not critical during that portion of the procedure. Test equipment used in a particular step should remain connected at the end of the step unless the instructions state otherwise. If you are performing only part of the procedure, it may be necessary to check back three or four steps to determine the test equipment connections and setting of controls. Be sure also to read the information given in the "Preliminary" step.

Do not preset internal controls unless the instrument has been repaired or is known to be seriously out of adjustment. If repairs have been made, preset internal controls to mid-range in the affected circuits.

RECOMMENDED EQUIPMENT

The following items of equipment (or their equivalents) are required for a complete calibration of the Type 555 Oscilloscope. The six-digit numbers in parentheses are Tektronix part numbers.

1. Two calibrated vertical plug-in units. One plug-in must be a Tektronix Type K Plug-In Unit. The other vertical plug-in unit may be any letter-series plug-in with a deflection factor range from .05 to 20 v/cm, 20 pf input capacitance and a bandpass to at least 20 mc with the Type 555 (see Table 1-1).

2. Variable autotransformer (e.g. Powerstat or Variac), with an output range to 125 volts (or 250 volts for nominal 230-volt operation) and a power rating of at least 1.3 kva.

3. Time-Mark Generator, Tektronix Type 180A, with time-mark and trigger outputs. Accuracy must be within 1%.

4. Constant-Amplitude Signal Generator, Tektronix Type 190B. Frequency range from 500 kc to at least 30 mc.

5. Plug-In Test Unit, Tektronix Type P or Tektronix Type TU-7 (for high frequency adjustments only).

6. Square-Wave Generator, Tektronix Type 107. Risettime less than 3 nsec.

7. Accurate DC voltmeter, with sensitivity of at least 5000 Ω/v , and checked for an accuracy within 1% at 100, 150, 225, 350 and 500 volts, and for an accuracy within 3% at 1350 volts. Portable multimeters should be checked regularly against accurate standards, and corrective readings noted where necessary, at the voltages listed above.

8. Accurate AC voltmeter, with range from zero to approximately 150 volts rms (or zero to approximately 300 volts rms for nominal 230-volt operation).

9. Accurate AC voltmeter, of iron vane or dynamometer type, with a range from zero to approximately 10 volts rms.

10. 10X Attenuator Probe, Tektronix P6006.

11. Two Time-Base Plug-In Extensions (013-013). A single extension may be used by adjusting one timing unit at a time.

12. Gain Adjust Adapter (013-005).

13. Clip-lead Adapter (013-076 for BNC, 013-003 for UHF) and a $\frac{1}{2}$ -watt 1 k composition resistor.

14. 50-ohm Termination, compatible with Type K Plug-In Unit (011-049 for BNC, 011-045 for UHF).

15. 42-inch 50-ohm coaxial cable with BNC connectors (012-057).

16. Two-inch 50-ohm coaxial cables with UHF or BNC connectors, depending on connector types on auxiliary equipment (012-057 for BNC, 012-001 for UHF).

17. Coaxial tee connector (103-030 for BNC, 103-026 for UHF).

18. BNC to binding-post adapter (103-033).

19. Two 18-inch insulated jumper leads with banana plug connectors (012-029).

20. One 6-inch insulated jumper lead with banana plug connectors (012-029).

21. Shorting strap illustrated in Fig. 5-4.

22. Low-capacitance calibration tools. See Fig. 6-1.

23. One or more of the following adapters may be required for connecting to test instruments or vertical plug-in units with different connector types:

UHF Male to BNC Female (103-015)

BNC Male to UHF Female (103-032)

BNC Male to Binding-Post (103-033)

24. The Type 555 is used as a test oscilloscope to make some of the adjustments by using single-beam operation.

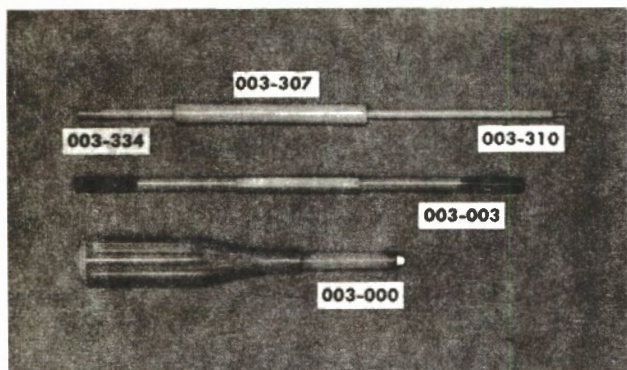


Fig. 6-1. Low-capacitance calibration tools, Tektronix part numbers indicated.

PROCEDURE

NOTE

The following procedure is for a Tektronix Type 555 Oscilloscope (Serial Number 7000 and up) with a Type 21A Time-Base Unit in the Time Base A plug-in compartment and a Type 22A Time-Base Unit in the Time Base B plug-in compartment.

Preliminary

Remove the side and bottom panels of the Power Supply and Indicator Units to be calibrated. Install the Type K Plug-In Unit in the Lower Beam compartment and the other vertical plug-in unit in the Upper Beam compartment. If a complete calibration is to be done, extend the time-base plug-in units by installing the plug-in extensions between the connectors on the plug-in units and those in the Indicator Unit.

Set front-panel controls as follows:

Upper Beam

INTENSITY	Counterclockwise
HORIZ. DISPLAY	TIME BASE A X1

Lower Beam

INTENSITY	Counterclockwise
HORIZ. DISPLAY	TIME BASE B X1

Time Base A and Time Base B

LEVEL	Clockwise
VERNIER	Centered
SLOPE	+
COUPLING	AC
TIME/CM	.5 mSEC
VARIABLE	CALIBRATED
SWEEP FUNCTION	NORMAL
Time Base A SOURCE	UPPER BEAM
Time Base B SOURCE	LOWER BEAM

Vertical Plug-In Units

Input Coupling	AC
Deflection Factor	.05 (cal.)

Set the AMPLITUDE CALIBRATOR switch to OFF. Check the rear panel of the instrument to be sure the metal straps are in place between the CRT CATHODE and GROUND connectors for both beams, and that both CHOPPED BLANKING-CRT CATHODE switches are in the CRT CATHODE position.

Connect the Indicator Unit of the Type 555 to the Power Supply Unit with the multi-lead power cable, and connect the Power Supply unit to the output of the autotransformer. Connect the 0-150-volt (or 0-300-volt) ac meter across the autotransformer output to monitor the output voltage. Turn on all equipment and adjust the autotransformer for the design-center voltage for which your instrument is wired (117 or 234 volts). Disconnect the meter.

Allow at least 10 minutes warm-up before making any adjustments.

POWER SUPPLY AND CRT ADJUSTMENTS

1. Adjust Low-Voltage Power Supplies

With the dc voltmeter, measure the output voltage of the —150, +100, +225, +350 and +500-volt supplies at the points indicated in the Power Supply Unit (Fig. 6-2). The output voltage of the —150-volt supply must be between —147 and —153 volts, and the other regulated supplies must be within 2% of their rated values. The —150 ADJ control, R616 (Fig. 6-3), can be set so that all of these voltages are within the specified tolerance. Remember, however, that the calibration of the entire instrument is affected by changes in the power supply voltages. Don't adjust the —150 ADJ control unless one or more of the supplies is actually out of tolerance.

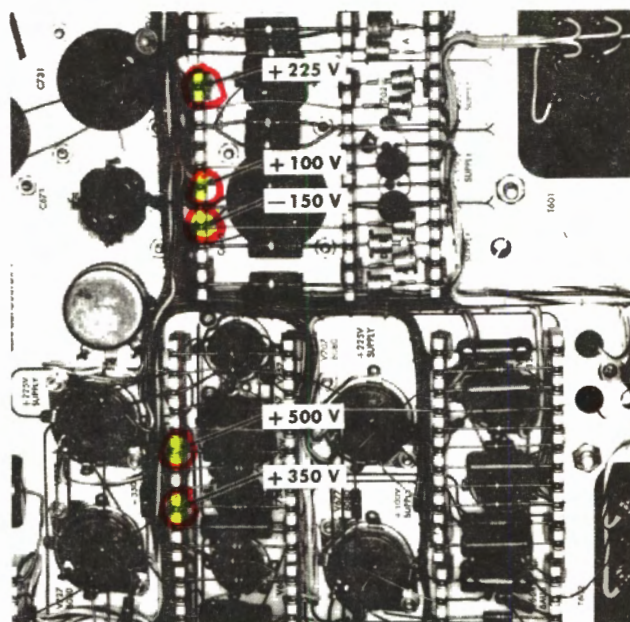


Fig. 6-2. Bottom view of Power Supply Unit showing low-voltage test points. Color-coded power-supply leads are connected at left side of each test point (see Maintenance section for color code).

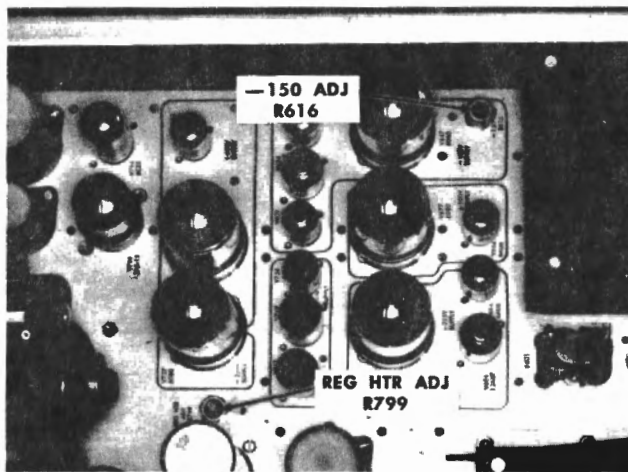


Fig. 6-3. Top view of Power Supply Unit showing calibration adjustments.

Connect the 0-10-volt rms ac meter between ground and the 6.3 VAC test point shown in Fig. 6-16. Check for a voltage reading of 6.3 volts ac and adjust R799, the REG HTR ADJ control, if necessary.

IMPORTANT NOTE

The voltage waveform of the regulated 6.3-volt ac heater supply is not a sine wave, therefore the voltage must be checked and adjusted using an rms-reading voltmeter (either iron-vane or dynamometer type). An ordinary average-reading voltmeter (d'Arsonval permanent-magnet movement) will average rather than integrate the waveform voltage, thus giving an incorrect reading.

2. Check Low-Voltage Regulation and Ripple

Check the regulated supplies for proper regulation by monitoring each voltage while varying the autotransformer output voltage from 105 to 125 volts (or 210 to 250 volts if the instrument is wired for 234-volt operation). All of the regulated dc voltages should remain essentially constant. The regulated ac heater supply should remain within $\pm 8\%$.

Typical ripple present on the regulated dc supplies is given in Table 6-1. The ripple is measured with the Lower Beam while the Upper Beam time-base generator is set so it will not sweep. The AMPLITUDE CALIBRATOR switch must be set to OFF position.

TABLE 6-1
Ripple on Low-Voltage Supplies

Supply Voltage	Typical Ripple	
	117 v (234 v)	105 or 125 v (210 or 250 v)
-150	5 mv	7.5 mv
+100	10 mv	15 mv
+225	5 mv	5 mv
+350	20 mv	30 mv
+500	20 mv	30 mv

Set the Time Base B SOURCE switch to LINE and the SWEEP FUNCTION switch to AUTO BASELINE. Connect one end of the coaxial cable to the INPUT connector of the Type K (Lower Beam) and attach the clip-lead adapter to the other end of the coax. Increase the Lower Beam intensity to display a free-running trace. Connect the outer conductor (black lead) of the clip-lead adapter to chassis ground. Touch the center conductor (red lead) to each of the low-voltage test points (Fig. 6-2) and observe the ripple on each of the power supply leads. Trigger with the Time Base B LEVEL and VERNIER controls. (If oscillations occur on the waveform, connect the 1k resistor in series with the center conductor).

Disconnect the clip-lead adapter and the coax cable. Reset the autotransformer output to the design-center voltage.

3. Adjust Amplitude Calibrator Voltage

Connect the dc voltmeter between the CAL TEST PT and ground (see Fig. 6-4). With the AMPLITUDE CALIBRATOR switch set to OFF position, check the meter for a reading of exactly +100 volts. If necessary adjust R879, the CAL ADJ control. The output peak-to-peak voltage will then be within 3% of the front-panel markings, as set by a series of precision resistors.

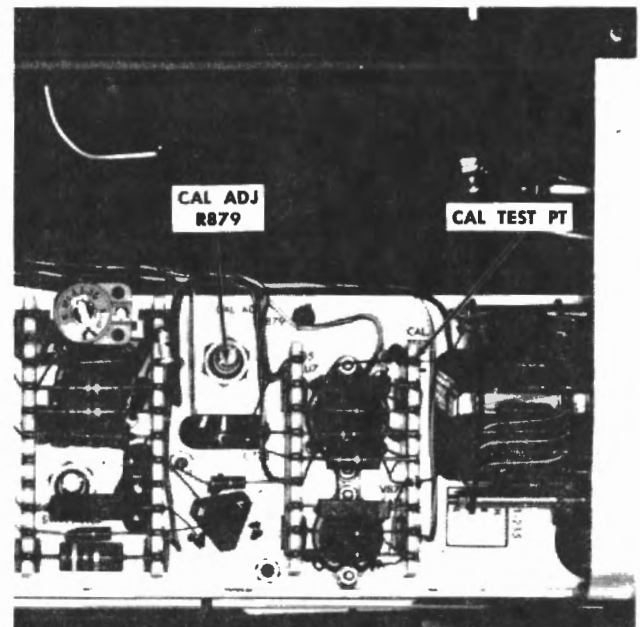


Fig. 6-4. Calibrator circuit in Indicator Unit.

Turn the AMPLITUDE CALIBRATOR switch to one of the output voltage settings. Check the meter for a reading between +45 and +55 volts at the CAL TEST PT. A voltage reading in this range indicates suitable symmetry of the calibrator waveform. A reading outside this range indicates that the multivibrator tubes, V875 and V885A, are not balanced, or some other components in the circuit are defective.

4. Adjust High-Voltage Supplies

The high-voltage adjustments of the two beams determine the total accelerating potential applied to the beams, and thus affect the deflection sensitivity.

a. Upper Beam

Connect the dc voltmeter between the Upper Beam —1350 TEST POINT and ground (see Fig. 6-5), and check for a meter reading of exactly —1350 volts. Adjust R852, the Upper Beam H V ADJ control, if necessary. If your meter has a maximum reading of 1200 volts, you can connect the positive meter lead to the —150-volt supply and set the Upper Beam H V ADJ control for a meter reading of —1200 volts.

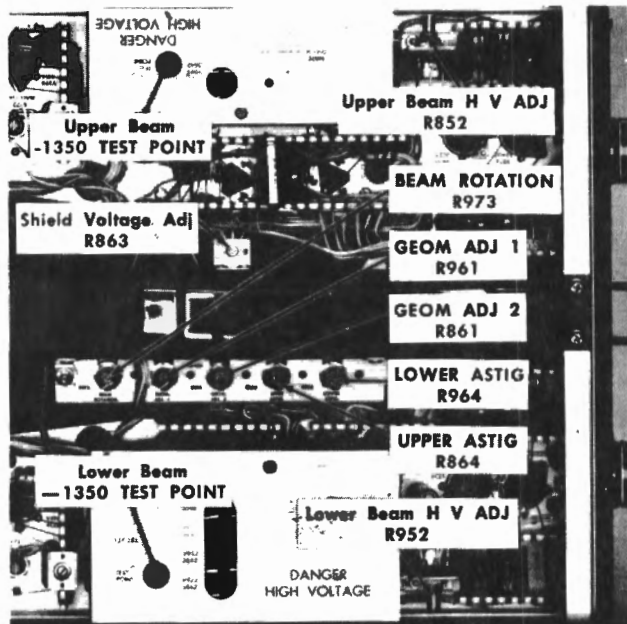


Fig. 6-5. Top view of Indicator Unit showing test points and crt adjustments.

b. Lower Beam

Connect the dc voltmeter between the Lower Beam —1350 TEST POINT and ground, and check for a meter reading of exactly —1350 volts. Adjust R952, the Lower Beam H V ADJ control, if necessary.

5. Adjust Trace Alignment

Controls should be set as follows:

Upper Beam	
HORIZ. DISPLAY	TIME BASE A X1
Lower Beam	
HORIZ. DISPLAY	TIME BASE B X1
Time Base A and Time Base B	
SOURCE	LOWER BEAM
SWEEP FUNCTION	AUTO BASELINE
TIME/CM	.5 mSEC
LEVEL	Clockwise
VERNIER	Centered

With no vertical input signals applied, center the traces on the crt with the Vertical Position controls using the beam indicator neons as a guide. Turn the INTENSITY controls

clockwise to display the two free-running traces, and adjust the FOCUS controls if necessary. Position the upper crt beam on the upper horizontal centerline, and the lower beam on the lower horizontal centerline.

Check the alignment of the traces relative to the horizontal graticule lines. If the traces are not aligned parallel to their respective centerlines, adjust R973, the BEAM ROTATION control. The location of the BEAM ROTATION control is shown in Fig. 6-5.

6. Adjust External Graticule (S/N's 7000-8999)

Leave the controls set as in the previous step. Position the Upper Beam trace upward until the trace dims, then downward until the trace again becomes dim. Position the beam midway between the two excursion limits. If the midway point does not coincide approximately with the upper horizontal centerline, remove the graticule cover and adjust the graticule position as follows:

Loosen the screw that holds the nylon cam in position at the lower left corner of the graticule. Rotate the cam with a small pointed tool to position the graticule centerline on the crt trace, then hold the cam and tighten the screw.

Check the Lower Beam viewing area to see that it is centered on the lower horizontal centerline. If not, reposition the cam to obtain a compromise graticule position for the two beams.

Replace the graticule cover.

7. Adjust Crt Vertical Sensitivity

Connect the two leads of the dc voltmeter to the two Lower Beam vertical deflection plate leads at the points shown in Fig. 6-6. Position the free-running Lower Beam trace on the lower horizontal centerline and note the voltage reading. Reposition the trace to the bottom graticule line (2 cm below the centerline) and again note the voltage reading. There should be a difference of 14.0 volts between the two readings to give a vertical sensitivity of 7.0 volts/cm. If the sensitivity is not correct, adjust R863, the SHIELD VOLTAGE ADJ control, until a difference of 14.0 volts is obtained between the two readings. See Fig. 6-5 for the location of R863.

Disconnect the meter leads.

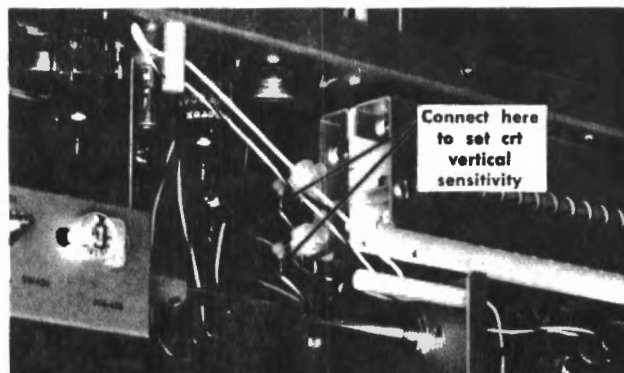


Fig. 6-6. Lower Beam vertical deflection plate connections.

8. Adjust Astigmatism

Set the SWEEP FUNCTION switches of both time-base units to NORMAL. Rotate both FOCUS controls fully clockwise, then place both HORIZ. DISPLAY switches at the EXT. ATTEN X10 position. With the HORIZ. POSITION controls, position both spots onto the crt screen and adjust the INTENSITY controls so the spots are not too bright. Adjust the UPPER ASTIG and LOWER ASTIG controls, R864 and R964, to make the defocused spots as circular as possible. (See Fig. 6-5 for the location of these controls). Adjust the front-panel FOCUS controls to bring the spots into sharp focus, then slightly readjust the UPPER ASTIG and LOWER ASTIG controls to produce the sharpest focus possible.

9. Adjust Geometry

Set controls to the following positions:

Upper Beam	
HORIZ. DISPLAY	TIME BASE A X1
Lower Beam	
INTENSITY	Counterclockwise
HORIZ. DISPLAY	TIME BASE B X1
Time Base A and Time Base B	
SWEEP FUNCTION	AUTO BASELINE
LEVEL	Clockwise
VERNIER	Centered
TIME/CM	1 mSEC
Time Base A SOURCE	UPPER BEAM
Time Base B SOURCE	LOWER BEAM
Vertical Plug-In Units	
Input Coupling	AC
Deflection Factor	1 v/cm (cal.)

a. Upper Beam

Set the AMPLITUDE CALIBRATOR switch to 10 VOLTS and connect the coax cable from the CAL. OUT connector to the INPUT of the Upper Beam vertical plug-in. Increase the Upper Beam intensity, then trigger the display with the Time Base A LEVEL control. The Upper Beam display should consist of a series of vertical lines. If the top or bottom of the calibrator waveform is visible, position it out of the viewing area.

Check to see that the displayed vertical lines are not bowed in or out (see Fig. 6-7). Use the HORIZ. POSITION control to position the waveform lines on each of the graticule edge lines. If the vertical lines are bowed, adjust R961, the GEOM ADJ 1 control, to display straight vertical lines parallel to the vertical graticule lines.

Turn the Upper Beam INTENSITY control fully counterclockwise.

b. Lower Beam

Move the calibrator signal to the INPUT of the Type K (Lower Beam) unit and check the Lower Beam geometry adjustment. Increase the Lower Beam intensity and trigger the display with the Time Base B LEVEL control. If the displayed lines are not straight, adjust R861, the GEOM ADJ 2 control.

Turn the Lower Beam INTENSITY control fully counterclockwise.

NOTE

500 microsecond markers from the time-mark generator may be used instead of the calibrator waveform for making the geometry adjustments. Position the baseline of the marker waveform below the viewing area of the beam.

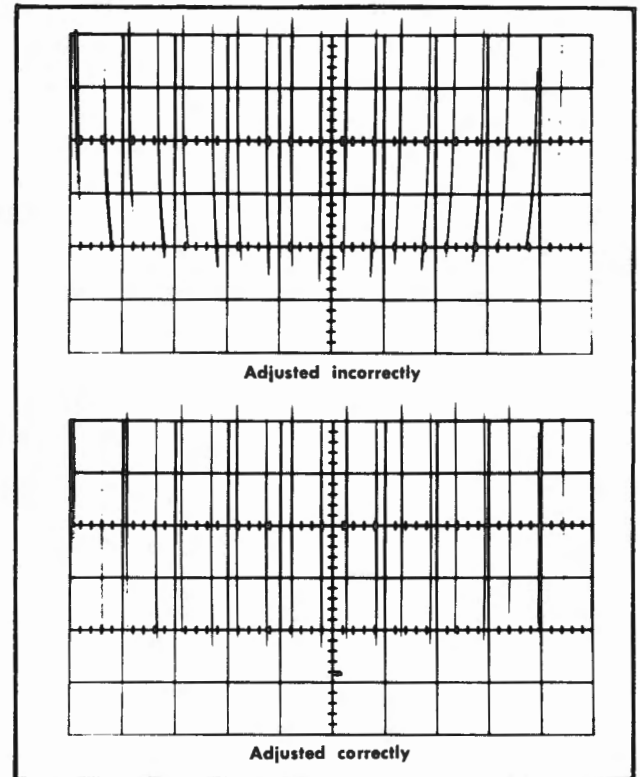


Fig. 6-7. Crt display for adjusting geometry controls.

10. Check Compression and Intensity Modulation

Reset both vertical input plug-in units for a deflection factor of 10 v/cm, calibrated. Connect a BNC tee between the CAL. OUT connector and the coax cable, and install a binding-post adapter on the second arm of the tee connector. Disconnect both rear-panel grounding straps between the CRT CATHODE and GND connectors.

a. Upper Beam Compression

Connect the coax cable to the Upper Beam vertical INPUT connector. Trigger the calibrator display and position the baseline of the waveform on the upper horizontal centerline. Adjust the gain of the Upper Beam plug-in unit to produce exactly 2 cm of deflection. With the Vertical Position control, position the display to the top and to the bottom of the viewing area and observe the trace closely. Compression or expansion at the top or bottom of the viewing area should not exceed 1 mm.

b. Upper Beam Intensity Modulation

Set the Upper Beam INTENSITY control to present a dim display. Connect two 18-inch jumper leads together and apply the calibrator signal to the Upper Beam CRT CATHODE connector. There should be appreciable difference in intensity between the top and bottom of the waveform. Set the AMPLITUDE CALIBRATOR switch to 20 VOLTS, and readjust the INTENSITY control so the brightest portion of the waveform is at normal intensity. The top portion of the calibrator signal should now be completely blanked. Remove the jumper leads.

c. Lower Beam Compression

Move the coax with the calibrator signal to the INPUT of the Lower Beam plug-in unit. Set the AMPLITUDE CALIBRATOR switch to 10 VOLTS. Adjust the gain of the Type K (Lower Beam) unit for 1 cm of deflection at the lower centerline. Check the Lower Beam for compression or expansion as described for the Upper Beam.

d. Lower Beam Intensity Modulation

Set the Lower Beam INTENSITY control for a dim display. Connect the calibrator signal to the Lower Beam CRT CATHODE connector and check the intensity modulation of the Lower Beam by the procedure described for the Upper Beam.

Remove the jumper leads and replace the ground straps between the rear-panel connectors.

TRIGGER ADJUSTMENTS

(S/N 11000-up)

The time-base triggering adjustments that follow should be made in the indicated sequence. The time-base plug-in units must be extended at this time if bias has not been done previously (see Preliminary step).

11A. Adjust Trigger Sensitivity, Centering and DC Level

Set the front-panel controls as follows:

Lower Beam

HORIZ DISPLAY TIME BASE A $\times 1$

Time Base A and Time Base B

SOURCE	LOWER BEAM
TIME/CM	.5 mSEC
SWEEP FUNCTION	AUTO BASELINE
LEVEL	Centered
VERNIER	Centered

Type K (Lower Beam)

AC-DC	AC
VOLTS/CM	.05
VARIABLE	CALIBRATED

Set the AMPLITUDE CALIBRATOR switch to 10 MILLIVOLTS.

R25 - SENSITIVITY
R26 - TRIG RING

a. Time Base A (Type 21A)

In the Time Base A plug-in unit, connect a shorting strap from ground to the junction of R18 and R19 (see Fig. 6-10a).

With the 10-mv calibrator signal applied to the INPUT connector of the Type K plug-in unit, center the Lower Beam waveform on the lower horizontal centerline. The waveform should be triggered. Set the AMPLITUDE CALIBRATOR switch to 5 MILLIVOLTS. The waveform should free run. Adjust R25 (TRIGGER SENSITIVITY) in the Time Base A plug-in unit (see Fig. 6-10a), if necessary, so that the display is triggered when the display amplitude is 2 millimeters (10 mv) and is free running when the display amplitude is 1 millimeter (5 mv).

Set the SLOPE switch to — and check for a triggered display with the AMPLITUDE CALIBRATOR switch set to 10 MILLIVOLTS and a free-running display with the switch set to 5 MILLIVOLTS. If triggering is not correct in + and/or — slope, adjust R25 TRIGGER SENSITIVITY and R26 TRIG LEVEL CENT in the Time Base A plug-in unit as follows:

Set the AMPLITUDE CALIBRATOR switch to 5 MILLIVOLTS. Set R25 to the fully clockwise position, then adjust R26 (see Fig. 6-8a) for a triggered display. Adjust R25 slowly counter-clockwise just until the display free runs with the SLOPE switch at either + or — position. With the SLOPE switch set at +, readjust R26 to the point that the display is triggered intermittently and note the setting of the potentiometer (R26). Set the SLOPE switch to —. Adjust R26 slowly clockwise until triggering of the display is again intermittent and note the setting of the control. (The range between the two points of intermittent triggering should be very narrow).

Recheck the adjustment of R25 with 2 millimeters and 1 millimeter of calibrator signal as described above and readjust R25 if necessary.

Disconnect the calibrator signal from the Type K plug-in unit.

Reset the following controls:

Time Base A and Time Base B

SOURCE	UPPER BEAM
COUPLING	DC
SWEEP FUNCTION	NORMAL
TIME/CM	5 mSEC

Vertical Plug-In Units

VOLTS/CM	.5 (cal.)
Input Coupling	DC

Install a 10 \times probe on the INPUT connector of the Upper Beam vertical plug-in unit and connect the tip of the probe to the junction of R25 and C5 in the Time Base A plug-in unit (see Fig. 6-10a). Be sure the probe is properly compensated. Set the INTENSITY controls to display the two traces on the screen. Center the Upper Beam display on the upper horizontal centerline.

Adjust R8, the UPPER BEAM TRIG DC LEVEL control in the Time Base A plug-in unit (see Fig. 6-10a) so the waveform starts positive just above the centerline with the SLOPE switch in the + position and starts negative just below the centerline with the SLOPE switch in the — position. The distance

between the centerline and the start of the trace should be approximately equal in + and — slopes.

Remove the probe from the INPUT of the Upper Beam vertical plug-in unit and connect it to the INPUT of the Type K (Lower Beam). Set the Time Base A SOURCE switch to LOWER BEAM. Center the Lower Beam display on the lower horizontal centerline. Adjust R3, the LOWER BEAM TRIG DC LEVEL control in the Time Base A plug-in unit so the waveform starts just above the centerline with the SLOPE switch in the + position and just below the centerline with the switch in the — position.

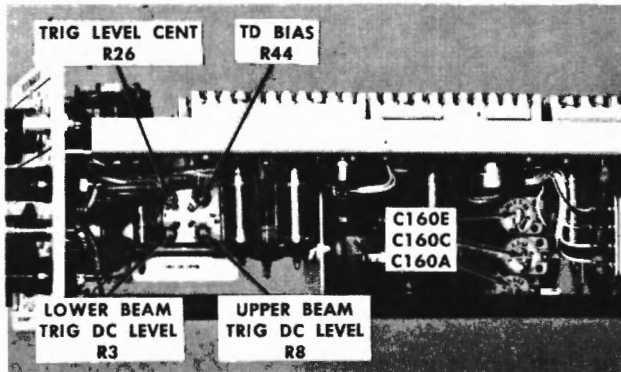


Fig. 6-8a. Left side view of Type 21A with Time Base A trigger and timing adjustments.

b. Time Base B (Type 22A)

Remove the probe tip from the Time Base A plug-in unit and disconnect the probe from the vertical INPUT connector. Move the shorting strap from the Time Base A plug-in unit to the junction of R18 and R19 in the Time Base B plug-in unit.

Set the following controls:

Upper Beam and Lower Beam

HORIZ DISPLAY TIME BASE B $\times 1$

Time Base B

SOURCE	LOWER BEAM
TIME/CM	.5 mSEC
SWEEP FUNCTION	AUTO BASELINE
SLOPE	+
COUPLING	AC

Vertical Plug-In Units

VOLTS/CM .05

Adjust the Time Base B TRIGGER SENSITIVITY control (R25), the TRIG LEVEL CENT control (R26) and the TRIG DC LEVEL controls (R8 and R3) in the manner just described for the corresponding Time Base A controls. See Fig. 6-9a for the locations of R26, R8 and R3. Throughout these Time Base B adjustments, leave the Upper Beam and Lower Beam HORIZ DISPLAY switches set to TIME BASE B $\times 1$.

At the end of this step, remove the shorting strap and disconnect the probe tip from the time-base unit.

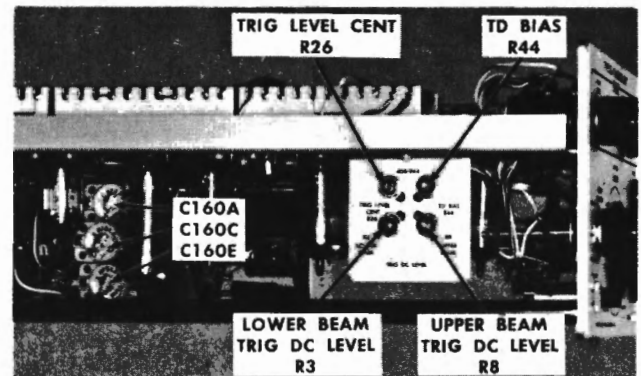


Fig. 6-9a. Right side view of Type 22A with Time Base B trigger and timing adjustments.

12A. Adjust Tunnel Diode Bias

Reset the following controls:

Lower Beam

HORIZ DISPLAY TIME BASE A $\times 1$

Time Base A

SOURCE	LOWER BEAM
TIME/CM	.1 μ SEC
SLOPE	+
COUPLING	AC

Time Base B

SOURCE	UPPER BEAM
TIME/CM	2 μ SEC
SLOPE	+
COUPLING	AC

Upper Beam Vertical Plug-In

Deflection Factor	1 volt/cm (cal.)
Input Coupling	AC

Type K (Lower Beam)

VOLTS/CM	.05
Input Coupling	AC

Install the $10\times$ probe on the INPUT connector of the Upper Beam vertical plug-in unit. Connect the output of the Type 190B Signal Generator to the INPUT connector of the Type K (Lower Beam). Set the signal generator for an output frequency of 30 mc and an output amplitude of approximately 100 millivolts.

a. Time Base A

Connect the tip of the probe to the junction of C131 and R132 in the Time Base A plug-in unit (see Fig. 6-10a). Trigger

the 30-mc sine-wave display with the Time Base A VERNIER control. Adjust the Output amplitude of the signal generator to produce 2 cm of deflection on the crt screen.

Trigger on Upper Beam display with the Time Base B LEVEL control and observe the trigger waveform. Adjust R44 TD BIAS (Fig. 6-8a) in the Time Base A plug-in unit for a maximum time period of 14.3 μ sec (7.15 cm) between cycles of the trigger waveform as the Time Base A VERNIER control is slowly turned through its triggering range.

b. Time Base B

Reset the following controls:

Upper Beam

HORIZ DISPLAY TIME BASE A $\times 1$

Lower Beam

HORIZ DISPLAY TIME BASE B $\times 1$

Time Base A

SOURCE UPPER BEAM
TIME/CM 2 μ SEC

Time Base B

SOURCE LOWER BEAM
TIME/CM .1 μ SEC

Move the tip of the probe from the Time Base A plug-in unit to the junction of C131 and R132 in the Time Base B plug-in unit (see Fig. 6-10a). Trigger the 30-mc sine-wave display with the Time Base B VERNIER control.

Trigger the Upper Beam display with the Time Base A VERNIER control and observe the triggering waveform. Adjust R44 TD BIAS (see Fig. 6-9a) in the Time Base B plug-in unit for a maximum period of 14.3 μ sec as the Time Base B VERNIER control is turned through its triggering range.

Remove the probe tip from the time-base unit and disconnect the 30-mc signal from the vertical plug-in unit.

13A. Adjust Stability

Reset the following controls:

Lower Beam

HORIZ DISPLAY TIME BASE A $\times 1$

Time Base A and Time Base B

SOURCE LOWER BEAM
TIME/CM .5 mSEC
LEVEL Centered

Upper Beam Vertical Plug-In

Deflection Factor 5 V/cm.(cal.)
Input Coupling DC

Connect the coax from the CAL OUT connector to the INPUT of the Type K (Lower Beam). Set the AMPLITUDE CALIBRATOR switch to 50 MILLIVOLTS.

a. Time Base A

With the 10 \times probe installed on the INPUT connector of the Upper Beam vertical plug-in unit, connect the probe tip to the center terminal of R111 (STABILITY) in the Time Base A plug-in unit. Trigger the display with the LEVEL and VERNIER controls. Adjust the Upper Beam intensity to present a free-running trace of normal intensity.

With an adjusting tool, turn the Time Base A STABILITY control fully counterclockwise, then turn it slowly clockwise until the traces of the two beams just appear on the screen. With the Upper Beam Vertical Position control, position the Upper Beam trace on the topmost graticule line. Continue turning the STABILITY control clockwise until the Lower Beam display begins to free run. Note the vertical position of the Upper Beam trace. Adjust the STABILITY control to position the Upper Beam trace midway between the topmost graticule line and the point where the Lower Beam trace began to free run.

b. Time Base B (Type 22A)

Move the probe tip to the center terminal of the Time Base B STABILITY control. Set both HORIZ DISPLAY switches to TIME BASE B $\times 1$, then adjust the Time Base B STABILITY control by the procedure just described for Time Base A.

After completing this step, disconnect the probe tip from the STABILITY control and remove the probe from the INPUT connector.

14A. Adjust Lockout Level

Reset the following controls:

Upper Beam

INTENSITY Counterclockwise

Lower Beam

HORIZ DISPLAY TIME BASE B $\times 1$

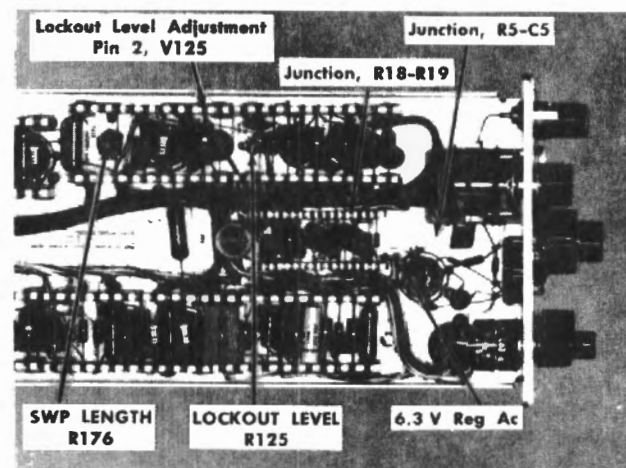


Fig. 6-10a. Top view of Time Base Unit showing test points and sweep adjustments.

a. Time Base A

With the coax cable connected from the CAL. OUT to the INPUT connector of the Type K, adjust the Time Base A LEVEL and VERNIER controls to trigger the square-wave display, then disconnect the coax cable from the INPUT of the Type K plug-in.

Set the Time Base A SWEEP FUNCTION switch to SINGLE SWEEP. Connect the dc voltmeter between ground and pin 2 of V125 in the Time Base A plug-in unit (see Fig. 6-10a).

Press and release the PUSH TO RESET button. The READY lamp inside the button should light and remain on. Note the voltage on the meter. Now, again connect the calibrator signal to the INPUT connector on the Type K. Following a single sweep of the trace, the meter should read 10 volts below the previous reading. If it does not, adjust the Time Base A LOCKOUT LEVEL control, R125, so the voltage on pin 2 will be just 10 volts below the first reading. Disconnect the meter leads.

Press and release the PUSH TO RESET button. The READY lamp should light each time the button is pressed and a triggered sweep should occur each time the button is released.

b. Time Base B

Set the Lower Beam HORIZ DISPLAY switch to TIME BASE B X1. Adjust the Time Base B LEVEL and VERNIER controls for a triggered display of the calibrator waveform, then disconnect the coax cable from the INPUT CONNECTOR.

Set the Time Base B SWEEP FUNCTION switch to SINGLE SWEEP. Connect the dc voltmeter between ground and pin 2 of V125 in the Time Base B plug-in and check the Time Base B LOCKOUT LEVEL adjustment and single sweep operation by the procedure just described for Time Base A. Remove the coax from the input of the Type K.

TRIGGER ADJUSTMENTS

(S/N 7000-10999)

The time-base triggering adjustments that follow must be made in the indicated sequence. The time-base units must be extended at this time if this has not been done previously (see "Preliminary" step).

11B. Adjust Tunnel Diode Bias

Set front-panel controls as follows:

Lower Beam

HORIZ. DISPLAY TIME BASE A X1

Time Base A and Time Base B

SOURCE	LOWER BEAM
TIME/CM	.5 mSEC
SWEEP MODE	NORMAL
LEVEL	Centered
VERNIER	Centered

Type K (Lower Beam)

AC-DC	DC
VOLTS/CM	1
VARIABLE	CALIBRATED

Set the AMPLITUDE CALIBRATOR switch to 1 VOLT. With the calibrator signal applied to the INPUT connector of the Type K plug-in unit, center the Lower Beam waveform on the lower horizontal centerline.

a. Time Base A (Type 21A)

Turn the Time Base A TD BIAS control (R44) fully counter-clockwise (see Fig. 6-8b for location of control), then turn it slowly clockwise until a stable display appears. Note the position of the TD BIAS control. Continue turning the control clockwise until the display free runs. Again note the position of the control. Set the TD BIAS control midway between the two positions just determined.

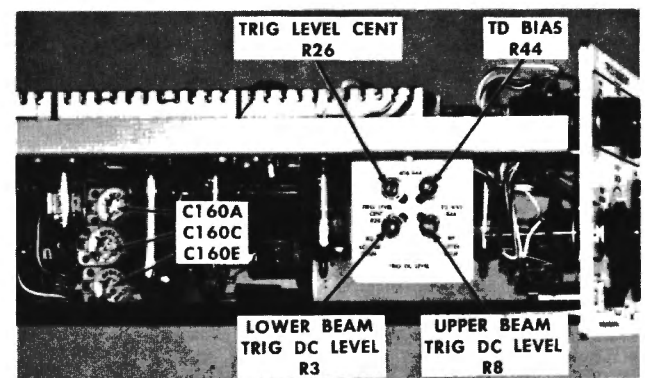


Fig. 6-8b. Left side view of Type 21A with Time Base A trigger and timing adjustments.

b. Time Base B (Type 22A)

Set the Lower Beam HORIZ. DISPLAY switch to TIME BASE B X1. Adjust the Time Base B TD BIAS control (R44) in the manner just described for Time Base A. See Fig. 6-9b for the location of the TD BIAS control in Time Base B.

Remove the coax cable and connectors after completing this step.

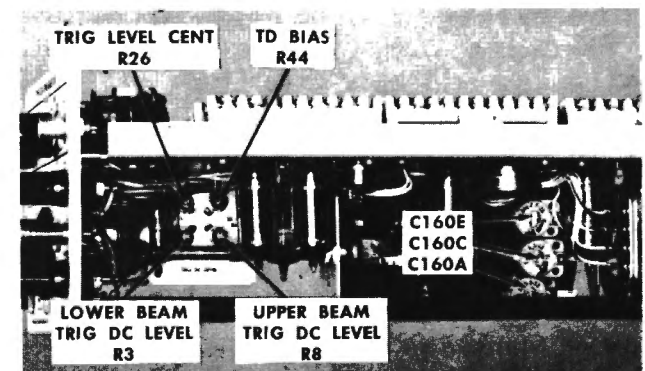


Fig. 6-9b. Right side view of Type 22A with Time Base B trigger and timing adjustments.

12B. Check H F Triggering

Reset the following controls:

Lower Beam

HORIZ. DISPLAY TIME BASE A X.2

Time Base A and Time Base B

TIME/CM .1 μ SEC
Time Base A SOURCE LOWER BEAM
Time Base B SOURCE UPPER BEAM

Set the Type 190B Signal Generator for an output frequency of 30 mc and an output amplitude of about 2.5 volts.

a. Time Base A

Connect the sine-wave signal to the INPUT connector of the Type K (Lower Beam). If necessary, trigger the display with the Time Base A VERNIER control. Adjust the output amplitude of the signal generator to produce 1 cm of deflection on the crt screen. A stable waveform should be displayed.

Set the Time Base A SOURCE switch to UPPER BEAM. The display should not trigger well at any position of the VERNIER control.

b. Time Base B

Set the Lower Beam HORIZ. DISPLAY switch to TIME BASE B X.2. Set the Time Base B SOURCE switch to LOWER BEAM. A stable waveform should be displayed. If necessary, trigger the display with the Time Base B VERNIER control.

Set the Time Base B SOURCE switch to UPPER BEAM. The display should not trigger well at any position of the VERNIER control.

Remove the input signal.

13B. Adjust Stability

Reset the following controls:

Upper Beam and Lower Beam

HORIZ. DISPLAY TIME BASE A X1

Time Base A and Time Base B

SOURCE LOWER BEAM
TIME/CM .5 mSEC

Upper Beam Vertical Plug-In

Deflection Factor 5 v/cm (cal.)
Input Coupling DC

Install the 10X probe on the INPUT connector of the Upper Beam vertical plug-in unit. Connect the coax from the CAL. OUT connector to the INPUT of the Type K (Lower Beam). Set the AMPLITUDE CALIBRATOR switch to 1 VOLT.

a. Time Base A

Connect the probe tip to the center terminal of R111 (STABILITY) in the Time Base A plug-in unit. Trigger the display with the LEVEL and VERNIER controls. Increase the Upper Beam intensity to present a free-running trace of normal intensity.

Turn the Time Base A STABILITY control fully counterclockwise, then turn it slowly clockwise until the traces of the two beams just appear on the screen. With the Upper Beam Ver-

tical Position control, position the Upper Beam trace on the topmost graticule line. Now turn the LEVEL control fully clockwise. The traces will disappear. Continue turning the STABILITY control clockwise until the traces again appear, with the Lower Beam display free running. Note the vertical position of the Upper Beam trace. Now center the LEVEL control and adjust the STABILITY control to position the Upper Beam trace midway between the topmost graticule line and the point where the Lower Beam trace began to free run.

b. Time Base B (Type 22A)

Move the probe tip to the center terminal of the Time Base B STABILITY control. Set both HORIZ. DISPLAY switches to TIME BASE B X1, then adjust the Time Base B STABILITY control by the procedure just described for Time Base A.

Disconnect the probe tip from the STABILITY control after completing this step.

14B. Adjust Lockout Level

Reset the following controls:

Upper Beam

INTENSITY Counterclockwise

Lower Beam

HORIZ. DISPLAY TIME BASE A X1

Type K (Lower Beam)

VOLTS/CM 1

a. Time Base A

With the coax cable connected from the CAL. OUT to the INPUT connector on the Type K, adjust the Time Base A LEVEL and VERNIER controls to trigger the square-wave display. Then disconnect the coax cable from the INPUT of the Type K Plug-In.

Set the Time Base A SWEEP FUNCTION switch to SINGLE SWEEP. Connect the dc voltmeter between ground and pin 2 of V125 in the Time Base A plug-in unit (see Fig. 6-10b).

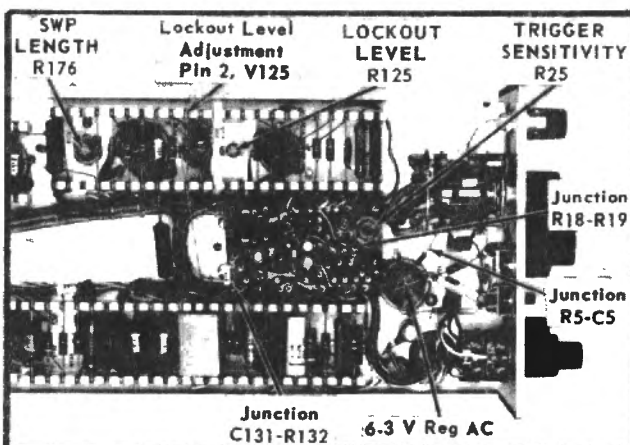


Fig. 6-10b. Top view of Time Base Unit showing test points and sweep adjustments.

Press the PUSH TO RESET button. The READY lamp inside the button should light and remain on. Note the voltage on the meter. Now, again connect the calibrator signal to the INPUT connector on the Type K. Following a single sweep of the trace, the meter should read 10 volts below the previous reading. If it does not, adjust the Time Base A LOCKOUT LEVEL control, R125, so the voltage on pin 2 will be just 10 volts below the first reading. Disconnect the meter leads.

Press the PUSH TO RESET button. One triggered sweep should now occur each time the button is pressed.

b. Time Base B

Set the Lower Beam HORIZ. DISPLAY switch to TIME BASE B X1. Adjust the Time Base B LEVEL and VERNIER controls for a triggered display of the calibrator waveform, then disconnect the coax cable from the INPUT connector.

Set the Time Base B SWEEP FUNCTION switch to SINGLE SWEEP. Connect the dc voltmeter between ground and pin 2 of V125 in the Time Base B plug-in unit and check the Time Base B LOCKOUT LEVEL adjustment and single sweep operation by the procedure just described for Time Base A.

Remove the coax from the input of the Type K.

15B Adjust Trigger Centering and Level

Reset the following controls:

Time Base A and Time Base B

SOURCE	UPPER BEAM
COUPLING	DC
SWEEP FUNCTION	NORMAL
TIME/CM	5 mSEC

Upper Beam and Lower Beam

HORIZ. DISPLAY	TIME BASE A X1
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Vertical Plug-In Units

Deflection Factor	.5 v/cm (cal.)
Input Coupling	DC

a. Time Base A

In the Time Base A plug-in unit, connect a shorting strap from ground to the junction of R18 and R19 (see Fig. 6-10b). With the 10X probe installed on the INPUT connector of the Upper Beam vertical plug-in unit, connect the tip of the probe to the junction of R5 and C5 in Time Base A. Set the INTENSITY controls to display the two traces on the screen. Center the Upper Beam display on the upper horizontal centerline.

In the Time Base A plug-in unit adjust R26, the TRIG LEVEL CENT control, so the waveform starts at the same dc level while the SLOPE switch is moved from + to —. Leave the SLOPE switch in the + position.

Adjust R8, the UPPER BEAM TRIG DC LEVEL control in Time Base A so the waveform starts positive at the centerline with the SLOPE switch in the + position and starts negative at the centerline with the SLOPE switch in the — position.

Remove the probe from the INPUT of the Upper Beam vertical plug-in unit and connect it to the INPUT of the Type K (Lower Beam). Set the Time Base A SOURCE switch to LOWER BEAM. Center the Lower Beam display on the lower horizontal centerline. In the Time Base A plug-in unit, adjust R3, the LOWER BEAM TRIG DC LEVEL control so the waveform starts at the centerline with the SLOPE switch in either the + or — position.

b. Time Base B

Move the shorting strap from Time Base A to the junction of R18 and R19 in Time Base B. Remove the probe from the INPUT of the Type K and install it on the INPUT of the Upper Beam vertical plug-in unit. The probe tip can be left connected to the Time Base A plug-in unit or moved to the junction of R5 and C5 in the Time Base B plug-in unit. Set both HORIZ. DISPLAY switches to TIME BASE B X1.

Center the Upper Beam display on the upper centerline. Now use the procedure just described for Time Base A to adjust R26 (TRIG LEVEL CENT), R8 (UPPER BEAM TRIG DC LEVEL) and R3 (LOWER BEAM TRIG DC LEVEL) in the Time Base B plug-in unit.

At the end of this step remove the shorting strap and the probe.

TIMING AND HORIZONTAL ADJUSTMENTS

For steps 16 through 20 leave both Time Base units extended from the Indicator Unit.

Install a coaxial tee connector on the INPUT of the Upper Beam vertical plug-in unit. Connect a coax cable from one end of the tee to the INPUT of the Type K (Lower Beam) unit. These connections will remain throughout the timing adjustments.

Set front-panel controls as follows:

Upper Beam and Lower Beam

HORIZ. DISPLAY	TIME BASE A X.2
----------------	-----------------

Time Base A and Time Base B

SWEEP FUNCTION	NORMAL
SOURCE	UPPER BEAM
TIME/CM	1 mSEC
SLOPE	+
COUPLING	AC
LEVEL	Clockwise
VERNIER	Centered

Vertical Plug-In Units

Deflection Factor	5 v/cm (cal.)
Input Coupling	AC

16. Adjust Magnifier Gain

Set the Type 180A Time-Mark Generator for an output of 100 microsecond markers and connect the output to the tee connector on the Upper Beam plug-in unit. Adjust the Time Base A LEVEL control to trigger the display.

Calibration — Type 555/21A/22A

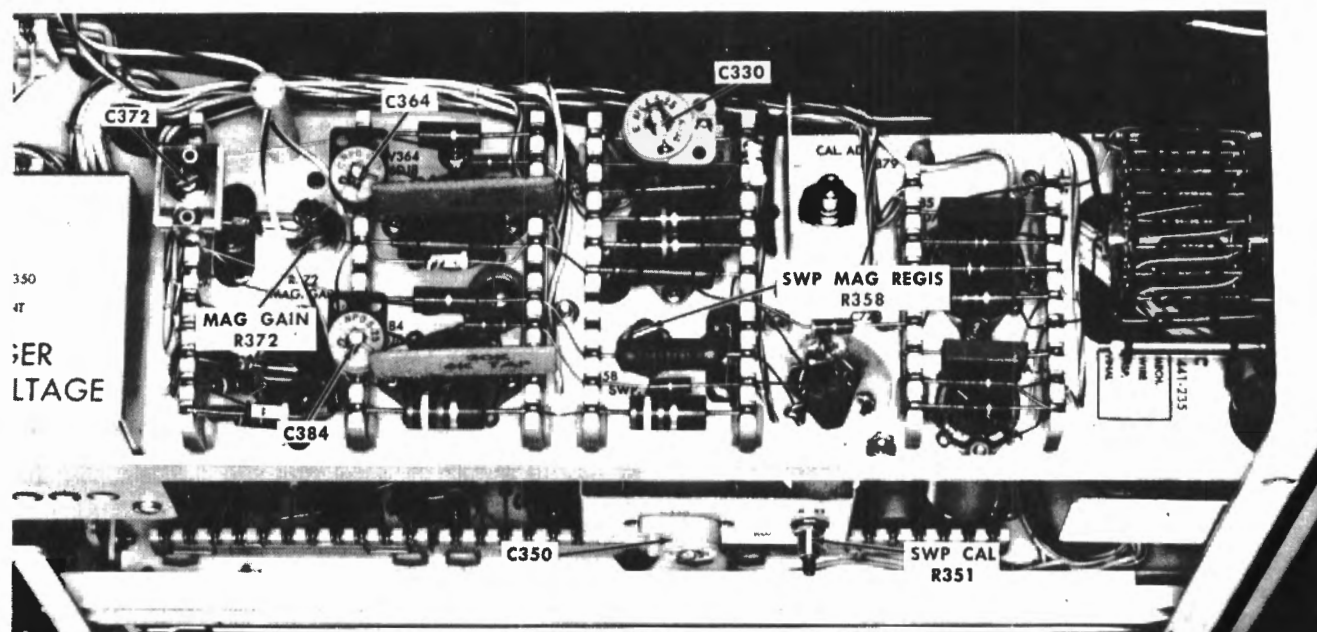


Fig. 6-11. Upper Beam Horizontal Amplifier circuit.

Check the Upper Beam display for exactly 2 time marks per cm between the 1 cm and 9 cm graticule lines. Adjust R372, the Upper Beam MAG GAIN control if necessary to obtain the proper display. The location of this control is shown in Fig. 6-11.

Check the Lower Beam display for exactly 2 time marks per cm between the 1 cm and 9 cm graticule lines. Adjust R472, the Lower Beam MAG GAIN control if necessary to obtain the proper display. See Fig. 6-12 for the location of R472.

17. Adjust Sweep Calibration

Set the time-mark generator for an output of 1 millisecond markers. Set the HORIZ. DISPLAY switches of both beams to TIME BASE A X1.

Check the Upper Beam display for exactly 1 time mark per cm between the 1 cm and 9 cm graticule lines, and adjust R351, the Upper Beam SWP CAL control, if necessary.

Check the Lower Beam display for exactly 1 time mark per cm between the 1 cm and 9 cm graticule lines, and adjust R451, the Lower Beam SWP CAL control, if necessary.

18. Adjust Sweep Magnifier Registration

Set the time-mark generator for 5 millisecond markers. Set the HORIZ. DISPLAY switches of both beams to TIME BASE A X.2, and focus both displays.

With the Upper Beam HORIZ. POSITION control, position the leading edge of the middle marker in the Upper Beam display on the vertical centerline of the graticule. Now set the Upper Beam HORIZ. DISPLAY switch to TIME BASE A X1. The leading edge of the middle marker should remain exactly on the centerline as the switch is moved from the

X.2 to the X1 position. If not, adjust R358, the Upper Beam SWP MAG REGIS control.

With the Lower Beam HORIZ. POSITION control, position the leading edge of the middle marker in the Lower Beam display on the vertical centerline. Now switch the Lower Beam HORIZ. DISPLAY to TIME BASE A X1. The leading edge of the middle marker should remain on the vertical centerline. If not, adjust R458, the Lower Beam SWP MAG REGIS control.

19. Adjust Sweep Length

With the time-mark signal still applied to the INPUT connectors, set the Lower Beam HORIZ. DISPLAY switch to TIME BASE B X1. Adjust the Time Base B LEVEL control for a stable display of the Lower Beam waveform.

a. Time Base A

Set the time-mark generator for 500 microsecond markers. In the Time Base A plug-in unit, adjust R176, the SWP LENGTH control, to display 10.5 cm of horizontal deflection (22 markers) of the Upper Beam display.

b. Time Base B

In Time Base B, adjust R176, the SWP LENGTH control, to display 10.5 cm of horizontal deflection (22 markers) of the Lower Beam display.

20. Check Variable Control

The VARIABLE control (R160Y) requires at least a 2.5-to-1 range to provide continuously variable sweep rates (uncalibrated) between the steps of the TIME/CM switch.

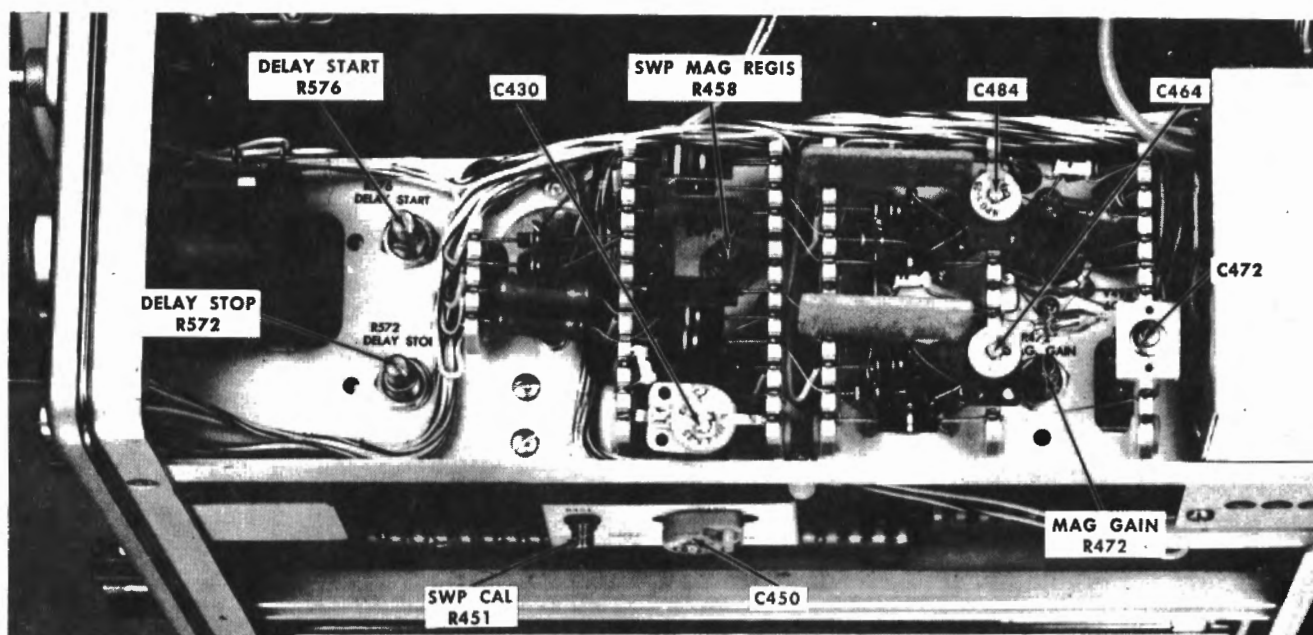


Fig. 6-12. Lower Beam Horizontal Amplifier circuit.

a. Time Base A

With the input signal connected as in step 19, set the time-mark generator for 5 millisecond markers. There should now be 1 marker displayed every 5 cm. Turn the Time Base A VARIABLE control fully counterclockwise. The markers in the Upper Beam display should now be less than 2 cm apart.

Check to see that the UNCALIBRATED neon lamp is on when the VARIABLE control is in any position except CALIBRATED.

b. Time Base B

Turn the Time Base B VARIABLE control fully counterclockwise. The markers in the Lower Beam display should now be less than 2 cm apart.

Check to see that the UNCALIBRATED neon lamp is on when the VARIABLE control is in any position except CALIBRATED.

IMPORTANT

For the remainder of the timing procedure (steps 21 through 27) the time-base units must be installed in the Indicator Unit and the side panels of the Indicator Unit must be in place. Turn off the power while removing the extensions, then allow a few minutes for warm up after applying power.

During the timing procedure, if an adjustment is required, remove the appropriate side panel temporarily to make the adjustment, then recheck the control setting with the side panel in place.

21. Check Sweep Rates

Front-panel controls should be set as follows:

Upper Beam and Lower Beam

HORIZ. DISPLAY

TIME BASE A X1

Time Base A and Time Base B

SOURCE	LOWER BEAM
SLOPE	+
COUPLING	AC
LEVEL	Centered
VERNIER	Centered
SWEEP FUNCTION	NORMAL
TIME/CM	.1 mSEC
VARIABLE	CALIBRATED

Vertical Plug-In Units

Deflection Factor	5 v/cm (cal.)
Input Coupling	AC

a. Time Base A

With the time-mark signal applied to both vertical INPUT connectors as in the previous steps, set the generator for 100 microsecond markers. Check the Time Base A sweep rates by applying the time marks listed in Table 6-2 and checking for the indicated displays between the 1 cm and 9 cm graticule lines. All positions of the TIME/CM switch must provide sweep rates within 3% accuracy (0.24 cm) over the center 8 cm of the screen. Typical accuracy is within 1%. (Remember that the time-mark generator may introduce $\pm 1\%$ error.)

b. Time Base B

Set the HORIZ. DISPLAY switches of both beams to TIME BASE B X1. Check the Time Base B sweep rates according to Table 6-2. All positions of the TIME/CM switch must provide sweep rates within 3% accuracy between the 1 cm and 9 cm graticule lines. Typical accuracy is within 1%.

TABLE 6-2
Sweep Rate Check

TIME/CM Switch	Time-Mark Generator	Observe
.1 msec	100 μ sec	1 mark/cm
.2 msec	100 μ sec	2 marks/cm
.5 msec	500 μ sec	1 mark/cm
1 msec	1 msec	1 mark/cm
2 msec	1 msec	2 marks/cm
5 msec	5 msec	1 mark/cm
10 msec	10 msec	1 mark/cm
20 msec	10 msec	2 marks/cm
50 msec	50 msec	1 mark/cm
.1 sec	100 msec	1 mark/cm
.2 sec	100 msec	2 marks/cm
.5 sec	500 msec	1 mark/cm
1 sec	1 sec	1 mark/cm
2 sec	1 sec	2 marks/cm
5 sec	5 sec	1 mark/cm

22. Adjust Sweep Range Registration

Reset the following controls:

Upper Beam and Lower Beam

HORIZ. DISPLAY TIME BASE B X.2

Time Base B

TIME/CM .1 mSEC

Vertical Plug-In Units

Deflection Factor 2 v/cm (cal.)

Set the time-mark generator for 1 microsecond time marks. With the two HORIZ. POSITION controls, position the first time marker of each display near the center of the graticule.

a. Upper Beam

Switch the Time Base B TIME/CM switch to 50 μ SEC, then back to .1 mSEC. There should be no horizontal movement of the first marker. Adjust C330 (see Fig. 6-11) if necessary, so the leading edge of the first marker in the Upper Beam display remains stationary as the TIME/CM switch is moved between the .1 mSEC and 50 μ SEC positions. Remove the adjustment tool from the capacitor while checking the registration.

b. Lower Beam

Adjust C430 (Fig. 6-12) if necessary, so the first marker in the Lower Beam display remains stationary as the TIME/CM switch is moved between the .1 mSEC and 50 μ SEC positions. Remove the adjustment tool while checking the registration.

23. Adjust HF Sweep Rates

Reset the following controls:

Upper Beam and Lower Beam

HORIZ. DISPLAY TIME BASE B X1

Time Base B

SOURCE EXT.
TIME/CM .5 μ SEC

a. Time Base B HF Range

Connect a cable from the trigger output of the time-mark generator to the external trigger INPUT on the Time Base B plug-in unit. (The time-mark signal should still be connected to the two vertical input connectors.) Set the time-mark generator for a 10 microsecond trigger output and a 1 microsecond marker output. Trigger the sweep with the Time Base B LEVEL control and check for a display of 1 mark every 2 cm between the 1 cm and 9 cm graticule lines. If not correct, adjust C160A in the Time Base B unit (see Fig. 6-9).

b. Horizontal Amplifiers

Set the Time Base B TIME/CM switch to .1 μ SEC and set the time-mark generator for a 10 mc sine-wave marker output. Check the display for linearity of the sweep and for 1 cycle/cm between the 1 cm and 9 cm graticule lines. Adjust the capacitors indicated below, if necessary.

Observe	Adjust	Location
Linearity	C372	Upper Beam Horiz. Amp (Fig. 6-11)
1 cycle/cm	C350	
Linearity	C472	Lower Beam Horiz. Amp (Fig. 6-12)
1 cycle/cm	C450	

Set both HORIZ. DISPLAY switches to TIME BASE B X.2. Reset the marker signal for 50 mc sine-waves and adjust the deflection factor of the vertical input plug-ins for about 2 cm of deflection. Check the displays for 1 cycle/cm between the 1 cm and 9 cm graticule lines. Adjust the timing capacitors indicated below if the sweep rates are not correct.

Observe	Adjust	Location
1 cycle/cm	C364 and C384	Upper Beam Horiz. Amp
1 cycle/cm	C464 and C484	Lower Beam Horiz. Amp

c. Time Base B Intermediate Ranges

Reset both HORIZ. DISPLAY switches to TIME BASE B X1. Set the external trigger rate to 100 microseconds. With the Time Base B TIME/CM switch and the marker signal set as indicated in the table below, check the sweep rates between the 1 cm and 9 cm graticule lines. Adjust the Time Base B timing capacitors if necessary. Each capacitor should be set for the optimum accuracy of the three sweep rates affected by the adjustment.

Time Base B TIME/CM	Time-Mark Generator	Observe	Adjust
1 μ SEC	1 μ sec markers	1 mark/cm	C160C
2 μ SEC	1 μ sec markers	2 marks/cm	
5 μ SEC	5 μ sec markers	1 mark/cm	
10 μ SEC	10 μ sec markers	1 mark/cm	C160E
20 μ SEC	10 μ sec markers	2 marks/cm	
50 μ SEC	50 μ sec markers	1 mark/cm	

If adjustments were required, it will be necessary to re-check this entire step because of the interaction of the controls.

Remove the external trigger signal from the trigger INPUT connector at the end of this step.

24. Adjust Delay Start and Stop

Reset the following controls:

Upper Beam

HORIZ. DISPLAY TIME BASE A X1

Time Base A

SOURCE UPPER BEAM
LEVEL Centered
TIME/CM 1 mSEC

Time Base B

SOURCE UPPER BEAM
SWEEP FUNCTION SWEEPS ONCE FOR
EACH 'A' DLY'D TRIG
LEVEL Clockwise
TIME/CM 10 μ SEC

Vertical Plug-In Units

Deflection Factor 5 v/cm (cal.)

Set the time-mark generator for 1 millisecond markers and trigger the displays with the Time Base A LEVEL control. Adjust both beams for normal intensity with a brightened portion visible on the Upper Beam trace.

Position both beams on their respective centerlines and set the DELAYED TRIGGER 1-10 MULTIPLIER to 1.00. The brightened portion of the Upper Beam display should be on the second time marker (1 cm from the left edge) and the leading edge of the magnified marker in the Lower Beam display should be at the left edge of the graticule (see Fig. 6-13). If the display is not correct, adjust R576, the DELAY START control.

Now turn the DELAYED TRIGGER 1-10 MULTIPLIER to 9.00. The brightened portion should be on the tenth time marker (1 cm from the right edge), and the leading edge of the magnified marker in the lower display should be at the left edge of the graticule as in the previous display. Adjust R572, the DELAY STOP control if the display is not correct.

The DELAY START and DELAY STOP adjustments interact with each other, therefore readjustment may be required. Re-check the settings of both controls if the DELAY STOP control required adjustment.

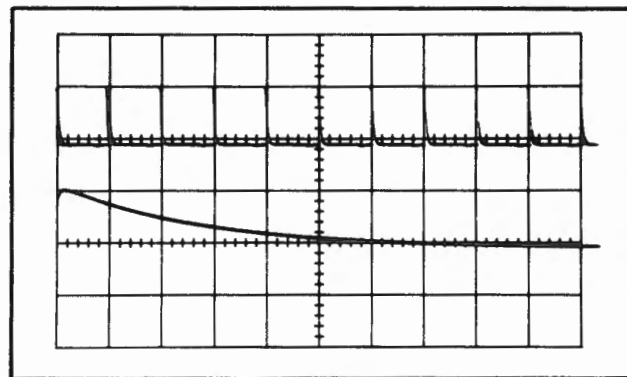


Fig. 6-13. Crt display with the DELAY START control correctly adjusted.

The brightened portion of the display should move smoothly across the screen as the 1-10 MULTIPLIER dial is turned.

25. Check Delayed Trigger

Leave connections and controls as they were at the end of the preceding step. Set the time-mark generator for 1 millisecond and 100 microsecond markers. Now set the Time Base B SWEEP FUNCTION switch to TRIGGERABLE ONCE FOR EACH 'A' DLY'D TRIG. Trigger the Upper Beam display on the tall markers with the Time Base A LEVEL control, and trigger the Lower Beam display on the shorter markers with the Time Base B LEVEL control. Turn the 1-10 MULTIPLIER dial slowly and observe the motion of the brightened portion of the trace. It should jump from marker to marker, rather than moving smoothly along the display.

Return the SWEEP FUNCTION switch to SWEEPS ONCE FOR EACH 'A' DLY'D TRIG.

26. Adjust 'A' Intermediate Sweep Rates

Because the Time Base A intermediate sweep rates are used in conjunction with Time Base B for Delayed Sweep operation, these sweep rates are adjusted with respect to Time Base B.

Reset the Time Base A TIME/CM switch to 10 μ SEC and the Time Base B TIME/CM switch to .5 μ SEC. With the marker signal connected to both vertical inputs as before, set the time-mark generator for 10 microsecond markers. Trigger the displays with the Time Base A LEVEL control.

Set the DELAYED TRIGGER 1-10 MULTIPLIER so the brightened portion of the Upper Beam display is on the second marker again and the leading edge of the marker in the Lower Beam display is at the left edge of the graticule. Note the setting of the 1-10 MULTIPLIER dial, add 8.00 to the reading, and reset the dial to the number determined by this addition. The brightened portion in the upper display should now be on the tenth marker and the leading edge of the marker in the lower display should be at the left edge of the graticule. If not, adjust C160E in the Time Base A plug-in unit.

With the TIME/CM switches and the time-mark generator set as indicated below, note the 1-10 MULTIPLIER dial readings with the brightened portion of the trace on the markers at the 1 cm and 9 cm graticule lines. The difference (delay time) between the two readings should be within 3% of 8.00 (i.e. 7.76 to 8.24). It may be advisable to readjust C160E slightly for optimum delay time accuracy of the three sweep rates affected.

Time-Mark Generator	Time Base A TIME/CM	Time Base B TIME/CM
10 μ sec markers	20 μ SEC	.5 μ SEC
50 μ sec markers	50 μ SEC	.5 μ SEC

Set the Time Base A TIME/CM switch to 1 μ SEC and the Time Base B TIME/CM switch to .1 μ SEC. Set the time-mark generator for 1 microsecond markers and turn the 1-10 MULTIPLIER dial to position the brightened portion on the second marker as before. Read the 1-10 MULTIPLIER dial, add 8.00 and reset the dial to the resultant number. The brightened portion of the Upper Beam display should now be on the tenth marker. If the leading edge of the magnified marker is not at the left edge of the graticule, adjust C160C in the Time Base A plug-in unit.

With the TIME/CM switches and the time-mark generator set as indicated below, note the 1-10 MULTIPLIER readings at the markers on the 1 cm and 9 cm graticule lines. Check the delay time for accuracy within 3%. C160C may be slightly readjusted to provide optimum delay accuracy for the three sweep rates.

Time-Mark Generator	Time Base A TIME/CM	Time Base B TIME/CM
1 μ sec markers	2 μ SEC	.1 μ SEC
5 μ sec markers	5 μ SEC	.1 μ SEC

27. Adjust 'A' HF Sweep Rates

Reset the following controls:

Lower Beam	
HORIZ. DISPLAY	TIME BASE A X1
Time Base A	
SOURCE	EXT.
Time Base B	
SWEEP FUNCTION	NORMAL

Connect a coax from the trigger output of the time-mark generator to the external trigger INPUT on the Time Base A plug-in unit and set the generator for 10-microsecond trigger pulses. With the Time Base A TIME/CM switch and the marker signal set as indicated below, check the sweep rates between the 1 cm and 9 cm graticule lines. Adjust C160A in the Time Base A unit if the sweep rates are not correct. The capacitor should be set for optimum accuracy of the three rates affected by the adjustment.

Time Base A TIME/CM	Time-Mark Generator	Observe
.1 μ SEC	10 mc sine waves	1 cycle/cm
.2 μ SEC	5 mc sine waves	1 cycle/cm
.5 μ SEC	1 μ sec markers	1 marker/2 cm

Remove all input cables, connectors and adapters after completion of this step.

28. Adjust Ext. Horiz. DC Balance

Controls should be set as follows:

Upper Beam and Lower Beam

INTENSITY	Counterclockwise
HORIZ. DISPLAY	EXT. ATTEN X1

Time Base A and Time Base B

SWEEP FUNCTION	NORMAL
LEVEL	Clockwise
TIME/CM	.5 mSEC
SLOPE	+
COUPLING	AC
SOURCE	EXT.

Vertical Plug-In Units

Deflection Factor	20 v/cm (cal.)
Input Coupling	AC

Center the two beams on the crt screen with the HORIZ. POSITION controls and adjust the INTENSITY controls to produce spots of normal brightness.

a. Upper Beam

Rotate the rear-panel Upper Beam EXT. HORIZ. GAIN control and observe the Upper Beam spot on the screen. If the spot moves horizontally, adjust R326, the Upper Beam EXT HORIZ AMP DC BAL control (Fig. 6-14) so there is no horizontal movement as the control is turned.

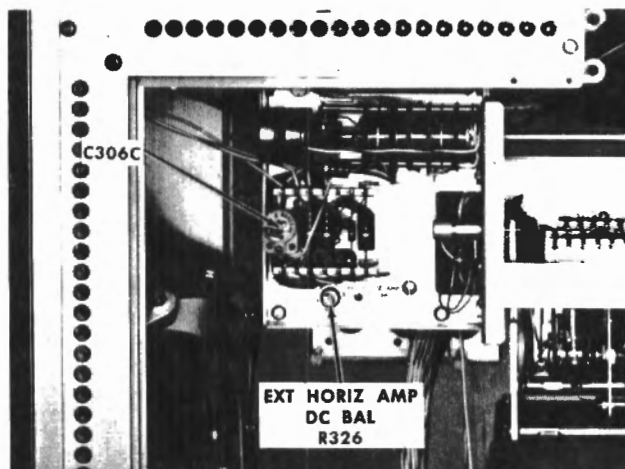


Fig. 6-14. Upper Beam External Horizontal Amplifier Circuit.

b. Lower Beam

Rotate the rear-panel Lower Beam EXT. HORIZ. GAIN control. If the spot moves horizontally on the crt screen, adjust R436, the Lower Beam EXT HORIZ AMP DC BAL control (Fig. 6-15) for no horizontal movement.

Leave both EXT. HORIZ. GAIN controls turned fully clockwise (as viewed from the rear of the instrument).

29. Check Ext. Horiz. Gain and Adjust Compensation

Install a BNC tee connector on the CAL. OUT and connect a binding-post adapter to one arm of the tee. Connect a coax cable from the other arm of the tee to the Time Base A external trigger INPUT connector.

a. Upper Beam

Set the AMPLITUDE CALIBRATOR switch to .2 VOLTS.

Connect two 18-inch jumper leads together and apply the Amplitude Calibrator signal from the binding-post adapter to the Upper Beam EXT. HORIZ. INPUT connector on the rear panel. Connect a short jumper lead from the Time Base A SAWTOOTH connector to the INPUT connector of the Upper Beam vertical plug-in. (A binding-post adapter or BNC-to-UHF adapter will be required if the input has a BNC type connector.) Position the Lower Beam spot off the crt screen. With front-panel controls set as in step 28, trigger the vertical square-wave display with the Time Base A LEVEL and VERNIER controls. At least 1 cm of horizontal deflection must be displayed with the EXT. HORIZ. GAIN control fully clockwise.

Switch the AMPLITUDE CALIBRATOR to 2 VOLTS. Position the baseline on the left edge of the graticule and adjust the Upper Beam EXT. HORIZ. GAIN control to display exactly 10 cm of horizontal deflection. Now set the Upper Beam HORIZ. DISPLAY switch to EXT. ATTEN X10. Center the display. Check for 1 cm of horizontal deflection ($\pm 3\%$).

Return the Upper Beam HORIZ. DISPLAY switch to EXT. ATTEN X1 and set the AMPLITUDE CALIBRATOR switch to .5 VOLTS. Note the waveshape of the square-wave display. Switch the AMPLITUDE CALIBRATOR to 5 VOLTS and the Upper Beam HORIZ. DISPLAY to EXT. ATTEN X10. Adjust C306C (Fig. 6-14) so the waveshape is the same as that observed at the X1 position.

Turn the Upper Beam INTENSITY control fully counterclockwise.

b. Lower Beam

Center the Lower Beam spot on the crt screen. Move the jumper lead with the calibrator signal to the Lower Beam rear-panel EXT. HORIZ. INPUT connector, and move the jumper with the Time Base A sawtooth waveform to the INPUT of the Type K (Lower Beam) unit. Set the AMPLITUDE CALIBRATOR switch to .2 VOLTS and trigger the vertical square-wave display. There must be at least 1 cm of horizontal deflection with the EXT. HORIZ. GAIN control turned fully clockwise.

Switch the AMPLITUDE CALIBRATOR to 2 VOLTS. Check the Lower Beam external horizontal attenuator accuracy and adjust the external horizontal input compensation by the procedure just described for the Upper Beam. Adjust C406C (Fig. 6-15) with the Lower Beam HORIZ. DISPLAY switch in the EXT. ATTEN X10 position.

At the end of this step, turn the Lower Beam INTENSITY control fully counterclockwise and remove all jumpers, cables and connectors.

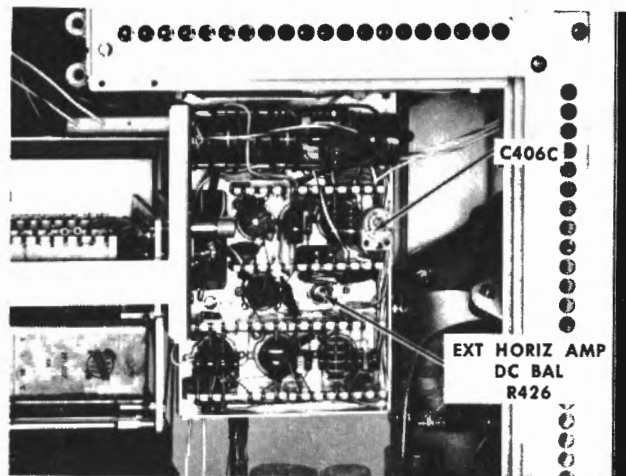


Fig. 6-15. Adjustments in Lower Beam External Horizontal Amplifier circuit.

30. Check Ext. Horiz. Passband

Reset the following controls:

Upper and Lower Beam

HORIZ. DISPLAY	EXT. ATTEN X1
EXT. HORIZ. GAIN	Clockwise

Set the Type 190B Constant Amplitude Signal Generator for a 50 kc output. Connect a 50-ohm termination to the attenuator head of the signal generator.

a. Upper Beam

Connect the terminated sine-wave signal to the rear-panel Upper Beam EXT. HORIZ. INPUT connector. Increase the Upper Beam intensity to normal and adjust the output amplitude of the signal generator to produce 4 cm of horizontal deflection on the crt screen. Set the frequency of the signal generator to 350 kc, then increase the output frequency until the deflection is 2.8 cm. The frequency should be at least 350 kc.

b. Lower Beam

Move the terminated signal to the Lower Beam EXT. HORIZ. INPUT connector. Set the signal generator for a 50 kc output signal. Check the passband of the Lower Beam External Horizontal Amplifier in the manner described for the Upper Beam.

Remove the signal from the EXT. HORIZ. INPUT.

VERTICAL AMPLIFIER ADJUSTMENTS

The adjustments for both vertical amplifiers are identical and are done in the same manner. Either Time Base unit may be used for the adjustments. In the following procedure, Time Base A is used to produce the Upper Beam sweep and Time Base B is used for the Lower Beam.

31. Set Vertical Amplifier Gain

Front-panel controls should be set as follows:

Upper Beam
HORIZ. DISPLAY TIME BASE A X1

Lower Beam
HORIZ. DISPLAY TIME BASE B X1

Time Base A and Time Base B
TIME/CM .5 mSEC
SWEEP FUNCTION AUTO BASELINE
LEVEL Clockwise

Time Base A SOURCE
Time Base B SOURCE

UPPER BEAM
LOWER BEAM

Vertical Plug-In Units

Deflection Factor 20 v/cm (cal.)
Input Coupling DC

Lay the Indicator Unit of the oscilloscope on one side.

a. Upper Beam

Turn off the instrument power and install the Gain Adjust Adapter between the interconnecting plug in the Upper Beam vertical plug-in and the jack in the plug-in compartment. Turn on the power and allow a few minutes for warm-up.

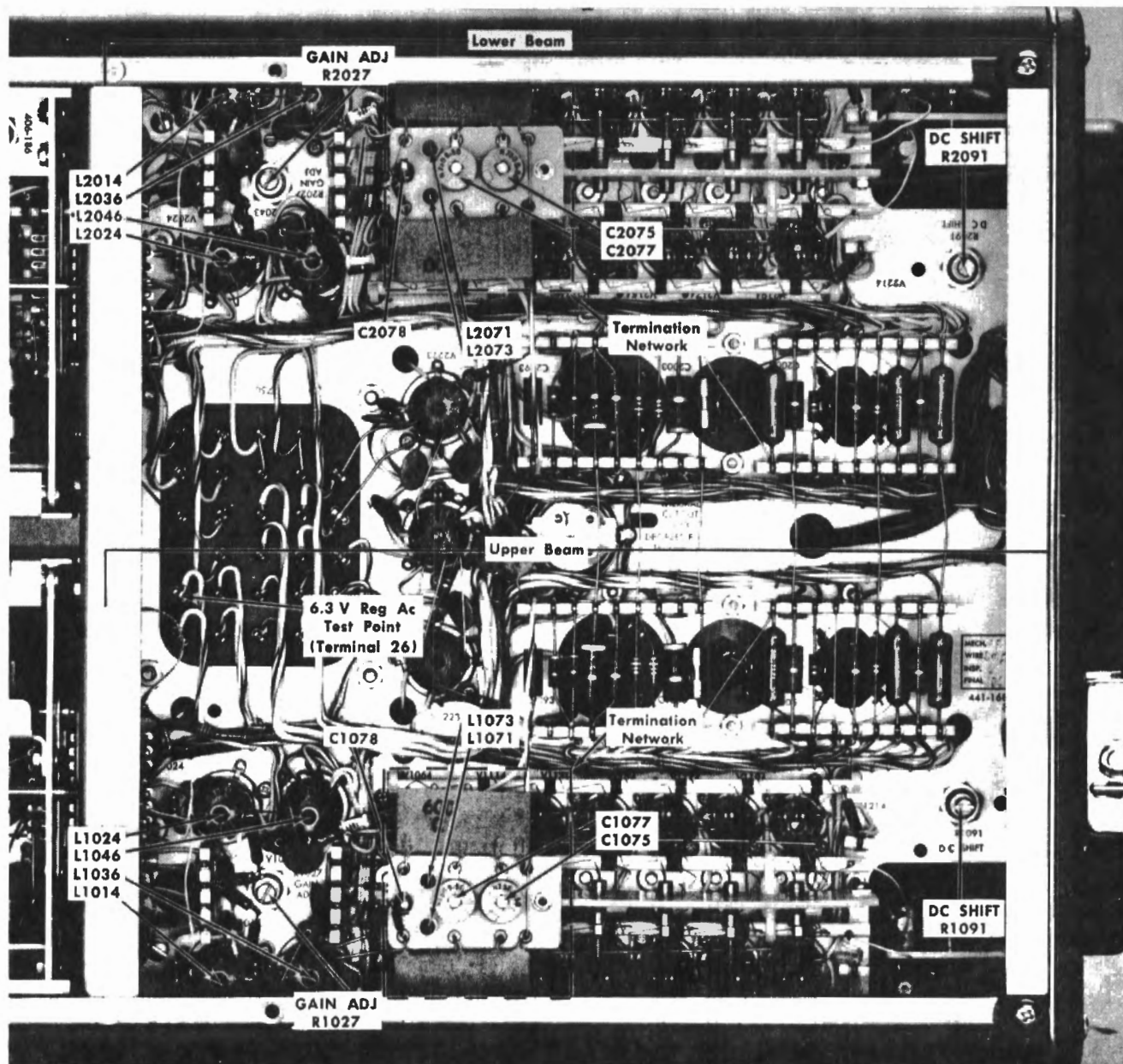


Fig. 6-16. Vertical Amplifier adjustments on bottom of Indicator Unit.

Install a binding-post adapter on the CAL. OUT connector and connect the calibrator signal to the Gain Adjust adapter with two jumper leads connected together. Set the AMPLITUDE CALIBRATOR switch to .2 VOLTS. Set the INTENSITY control for normal brightness and adjust the Time Base A LEVEL control for a stable display. Check for a vertical deflection of exactly 2 cm. If the display amplitude is incorrect, adjust R1027, the Upper Beam GAIN ADJ control (see Fig. 6-16).

Remove the jumper and Gain Adjust Adapter and reinsert the plug-in unit.

b. Lower Beam

Install the Gain Adjust Adapter between the Lower Beam vertical plug-in unit and the Indicator Unit. Apply the calibrator waveform to the adapter and check for 2 cm of vertical deflection. Adjust R2027, the Lower Beam GAIN ADJ control, if the gain of the Lower Beam Vertical Amplifier is not correct.

Remove the jumper and adapter and reinstall the Type K in the Lower Beam vertical plug-in compartment.

32. Adjust DC Shift

Reset both TIME/CM switches to .5 SEC and adjust the INTENSITY controls for normal brightness. Set the deflection factor of each vertical plug-in to 5 volts.

a. Upper Beam

Install the 10X probe on the INPUT connector of the Upper Beam vertical plug-in unit. Connect the probe tip to the —150-volt supply lead in the Power Supply Unit or to one of the other regulated dc supplies.

Position the free-running trace (spot) on the upper horizontal centerline. Now switch the input coupling switch to AC—the trace should move off the screen. Leave the switch at AC for about 5 seconds, then when the horizontal beam-indicator neons show the spot is approaching the center of the screen, switch back to DC. The spot should appear approximately on the centerline and remain there as it proceeds across the screen. If it starts somewhere off center and curves slowly toward the centerline, adjust R1091, the Upper Beam DC SHIFT control so that the spot appears and remains within 1 millimeter of the centerline after switching back to DC. See Fig. 6-16 for the location of the DC SHIFT controls.

It may be necessary to slightly readjust the quiescent level of the trace with the Vertical Position control during this procedure if the setting of the DC SHIFT control is changed.

b. Lower Beam

Move the probe cable from the Upper Beam vertical plug-in to the INPUT of the Type K (Lower Beam). With the probe tip connected to one of the regulated dc voltages, position the free-running spot on the lower centerline, then switch the input coupling to AC. After about 5 seconds, switch back to DC and watch the motion of the spot. If necessary, adjust R2091, the Lower Beam DC SHIFT control, so the spot appears and remains within 1 millimeter of the centerline after switching to DC.

Remove the probe and set the Indicator Unit upright for the following checks.

HIGH-FREQUENCY ADJUSTMENTS

The Vertical Amplifier high-frequency and delay line compensation controls are the most difficult and time-consuming adjustments to be made. These controls require only occasional readjustment after the initial factory calibration, therefore it is recommended that they not be changed during normal periodic recalibration unless they are degrading the high-frequency response. However, the vertical response should be checked each time the instrument is calibrated.

The vertical deflection system of the oscilloscope is designed to respond equally well to voltage information at all sine-wave frequencies from dc to 30 mc. (The upper-limit frequency response of the system will depend on the passband of the particular plug-in unit used.) This portion of the calibration procedure provides a complete check of the vertical high-frequency operation by observation of the response to a fast-rise (step function) input signal. Also provided here are the procedures necessary for checking the Vertical Amplifier tubes and adjusting the compensation controls if the high-frequency operation of the system is not satisfactory.

33. Check Transient Response

To check the vertical system an input pulse with a risetime no longer than 3 nsec is applied and the response noted in the displayed waveform on the crt screen. The high-frequency information is contained in the pulse rise and the first 450 nsec following the rise.

a. Upper Beam

Turn off the oscilloscope power and install the Type K Plug-In Unit in the Upper Beam plug-in compartment and the other vertical unit in the Lower Beam compartment. Turn on the instrument and allow at least 15 minutes warm-up time before making this check. Set the AMPLITUDE CALIBRATOR switch to OFF.

Front-panel controls should be set as follows:

Upper Beam

INTENSITY	Counterclockwise
HORIZ. DISPLAY	TIME BASE A X1

Lower Beam

INTENSITY	Counterclockwise
HORIZ. DISPLAY	TIME BASE B X1

Time Base A and Time Base B

TIME/CM	.5 μ SEC
VARIABLE	CALIBRATED
SWEEP FUNCTION	NORMAL
LEVEL	Clockwise
VERNIER	Centered
SLOPE	—
COUPLING	AC
Time Base A SOURCE	UPPER BEAM
Time Base B SOURCE	LOWER BEAM

Type K Plug-In Unit

VOLTS/CM	.05
VARIABLE	CALIBRATED
AC-DC	AC

The VOLTS/CM switch and VARIABLE controls must be left in these positions throughout the high-frequency checks. Use the controls on the square-wave generator for changing the display amplitude. Triggering will be done on the negative slope so there will be no irregularities on the pulse top as a result of triggering.

Adjust the DC Balance of the Type K as described in the manual for the plug-in unit. Install a 50-ohm termination on the INPUT connector of the Type K and connect a coax cable from the output of the Type 107 Square-Wave Generator to the termination. Set the square-wave generator for an output frequency of approximately 500 kc and an output amplitude of approximately 0.3 volts.

Position the Upper Beam display on the crt screen and turn the Upper Beam INTENSITY control to present a display that is slightly dimmer than normal. Trigger the waveform with the Time Base A LEVEL control. Adjust the FOCUS for a sharp trace. With the Amplitude control on the square-wave generator, adjust the display amplitude for approximately 3 cm of deflection.

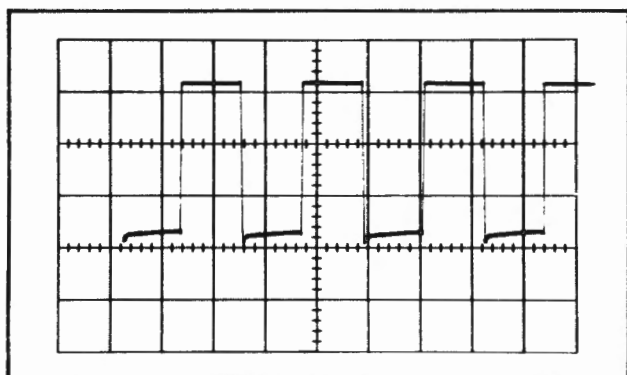


Fig. 6-17. High-frequency response to voltage step input, triggering on negative slope, with sweep rate set at $.5 \mu\text{sec}/\text{cm}$.

Compare the crt presentation with the waveform shown in Fig. 6-17. The top of each square-wave cycle should be level and smooth, and should be parallel with the horizontal graticule lines. The top should also appear level with the TIME/CM switch in the 1, 2 and 5 μSEC positions.

Return the TIME/CM switch to $.5 \mu\text{SEC}$. Set the Upper Beam HORIZ. DISPLAY switch to TIME BASE A X.2. With the HORIZ. POSITION control, center the first positive square-wave pulse on the crt screen. Compare the display with Fig. 6-18. The top of the pulse should be smooth with no irregularities in excess of one tracewidth. The front corner should be square with no appreciable overshoot or rolloff.

Set the Time Base A TIME/CM switch to $.1 \mu\text{SEC}$. Center the rising portion of the square-wave pulse. Decrease the display amplitude to present exactly 2.5 cm of deflection and position the pulse rise as indicated in Fig. 6-19. Using the

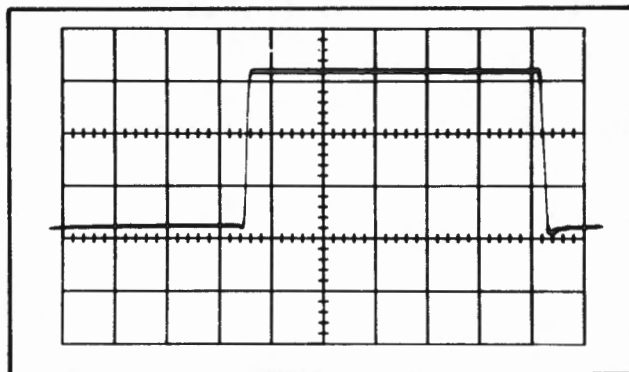


Fig. 6-18. High-frequency pulse appearance with sweep rate of $.1 \mu\text{sec}/\text{cm}$.

graticule as a reference, measure the 10% to 90% risetime of the pulse. This should be no longer than 12 nsec with a Type K Plug-In Unit in the Type 555.

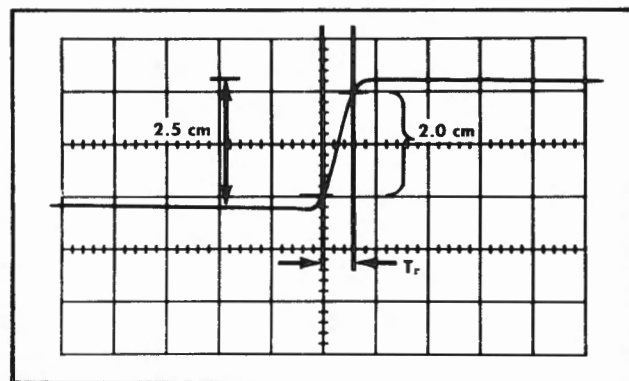


Fig. 6-19. Appearance of fast-rise pulse with sweep rate of $.02 \mu\text{sec}/\text{cm}$, for checking system risetime.

b. Lower Beam

Turn off the oscilloscope power. Remove both vertical plug-in units, then insert the Type K in the Lower Beam compartment and the other unit in the Upper Beam compartment. Turn the power on again and allow at least 10 minutes warm up. Allow 15 to 20 minutes if the instruments have been allowed to cool. Reset the front-panel controls to the positions given at the first of this step.

Connect the signal from the square-wave generator to the INPUT of the Type K through the 50-ohm termination, and position the Lower Beam display on the crt screen. Turn the Lower Beam INTENSITY control to present a display slightly dimmer than normal. Trigger the display with the Time Base B LEVEL control. Check the high-frequency characteristics of the Lower Beam Vertical Amplifier and delay line as described in the previous paragraphs for the Upper Beam.

NOTE

If the high-frequency characteristics of the Vertical Amplifiers and delay lines are satisfactory as indicated by the preceding checks, do not make any

adjustments or exchange any tubes. Omit steps 34 through 36 and proceed directly to the passband check, step 37.

34. Analysis of the Display

If the previous checks indicated that the high-frequency operation of the vertical system is not up to specifications, the tubes in the Vertical Amplifier should be checked first as described below, and perhaps some adjustments will be required of the compensation controls.

The operating characteristics and balance of the Vertical Amplifier tubes are critical for the high-frequency operation of the instrument. A change in the transient response of the system is usually caused by changes in the operating characteristics of these tubes and the tubes in the vertical plug-in unit. Since tube characteristics normally change over a period of time, it may be necessary to replace them occasionally to restore proper high-frequency response. By replacing tubes before extensive changes have taken place in their operating characteristics, adjustment of the high-frequency compensation controls will be minimized.

If there were minor irregularities in the top of the pulse in the previous check, but the top was generally level and the risetime was less than 12 nsec, the irregularities can be removed as described in step 36c. Keep in mind, however, that even minor irregularities may indicate that the Vertical Amplifier tubes are beginning to change their characteristics. If the compensation controls have frequently been adjusted to remove minor irregularities, the Vertical Amplifier tubes should be checked.

If the part of the pulse top affected by the high-frequency controls was quite irregular, sloping, or at an incorrect level, the Vertical Amplifier tubes should be checked for correct voltages and balance as described below. In general, these

conditions do not become severe until the Vertical Amplifier tubes have changed their operating characteristics considerably (or unless the compensation controls have been previously misadjusted).

If the risetime was longer than 12 nsec with the Type K Plug-In Unit, turn off the instrument power and replace the Type K with a Type P or Type TU-7 Test Unit. Turn on the power and allow 10 to 15 minutes warm-up. Check the risetime with the test unit. (If the display amplitude cannot be reduced to 2.5 cm, use 4 cm of vertical deflection and check the risetime over the center 3.6 cm.) With the plug-in test units, risetime of the system should be less than 10 nsec. If the risetime with the Type K was longer than 12 nsec, but is less than 10 nsec with the test unit, the Type K was causing the rolloff and should be recalibrated. If the risetime is still too long, first check the Vertical Amplifier tubes as described below. Remove the plug-in test unit and reinstall the Type K.

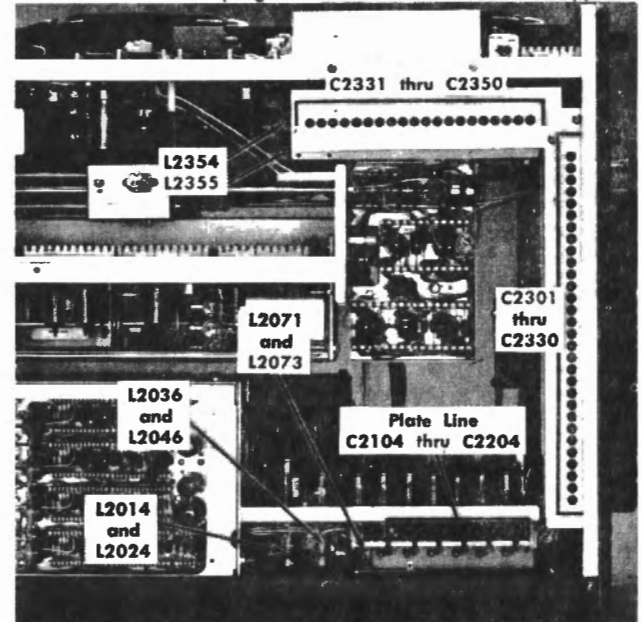


Fig. 6-21. Location of Lower Beam delay line adjustments.

After the Vertical Amplifier tubes have been checked and replaced as necessary, if the high-frequency characteristics are still not satisfactory, the delay line and possibly the high-frequency inductors will require adjustment. The locations of these controls are shown in Figs. 6-16, 6-20 and 6-21. The controls to be adjusted can be determined from the display of the fast-rise pulse.

NOTE

Due to the extensive interaction between the numerous high-frequency compensation controls, correct adjustment of these controls is difficult and should not be attempted unless it is absolutely necessary. These adjustments require a calibrator with good eyesight, manual dexterity, perseverance and a considerable amount of time.

The displayed pulse may be divided into three general areas: the rise, the front corner and the top. Each of the

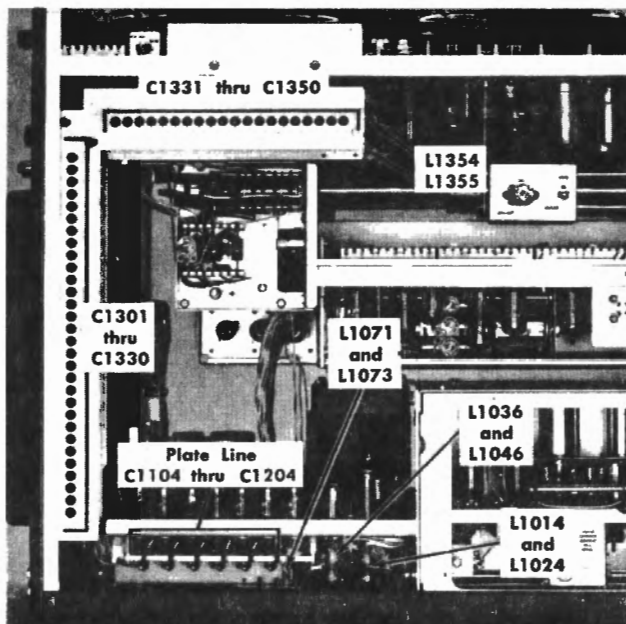


Fig. 6-20. Location of Upper Beam delay line adjustments.

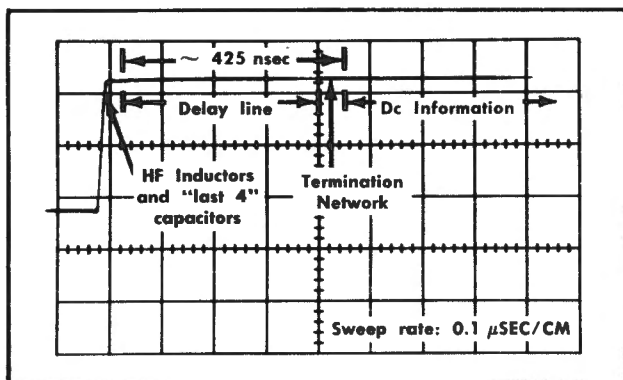


Fig. 6-22. Portions of the displayed pulse related to the high-frequency adjustments.

high-frequency compensation controls affects a particular point on the display. Fig. 6-22 relates the displayed pulse to the oscilloscope controls that affect the appearance of the various portions of the waveform. The upper part of the rise, the front corner, and the first 25 nsec following the corner are controlled primarily by the high-frequency inductors in the Vertical Amplifier and by the inductors and capacitors at the crt end of the delay line. The next 425 nsec of the pulse top is controlled by the delay line and termination adjustments. The final portion of the pulse contains only dc information and is not affected by the compensation controls. This portion is used as the reference level for adjusting the pulse top.

Distortion in the top of the pulse is usually caused by impedance mismatches in the delay line and termination network. Since the delay line is reverse terminated, the controls nearest the crt affect the portion of the display nearest the front corner. The effect of any particular delay line capacitor on the displayed pulse depends also on the setting of adjacent capacitors.

All of the trimmer capacitors in the delay line and plate line, as well as the capacitors and inductors in the termination network affect the display similarly and are adjusted in the same manner. During the procedure given below, all of these controls will be referred to as the delay line.

35. Check Vertical Amplifier Tubes

Lay the oscilloscope on one side to reveal the Vertical Amplifier circuitry. Fig. 6-16 shows the locations of test points used in the following checks. The circuit numbers given are those for the Upper Beam Vertical Amplifier. The procedure applies equally well for the Lower Beam.

The tubes in the Vertical Amplifier circuits are arranged in pairs that balance each other and must be closely matched to avoid distortion of high-frequency signals. The two tubes of a pair are positioned side-by-side on the chassis.

a. Suppressor Grid Voltage

With the dc voltmeter, check the voltage at the suppressor grid (pin 7) of each of the distributed amplifier tubes. The voltage must be between +165 and +185 volts. Replace any tube that has a suppressor voltage outside this range, if measured with a 20,000 Ω /volt meter. (Voltage must be at least +150 volts if measured with a 5000 Ω /volt meter.)

b. Grid Bias

Short the two distributed amplifier grid lines together with the shorting strap. This may be done by connecting to pin 1 of V1054 and pin 1 of V1064. With a dc voltmeter, measure the grid bias of each pair of tubes by checking the voltage between the grid line and either cathode (pin 2). Replace both tubes of any pair not having bias between -1 and -2.5 volts. Bias, and the balance which is dependent on bias, changes during the first few hours of operation of new tubes. Therefore new replacement tubes should be operated for at least 10 hours before checking their balance.

c. Overall Balance

Set the SWEEP FUNCTION switch to AUTO BASELINE, turn the LEVEL control fully clockwise and center the free-running trace. Determine the electrical center of the crt beam by shorting the vertical deflection plates together (not to ground). Note the position of the trace. This position will be used as a reference for checking balance. Remove the short and position the trace to the electrical center just determined.

Now short together pins 1 and 3 on the vertical plug-in interconnecting socket. This will determine the overall balance of the Vertical Amplifier. The trace should not shift more than 1 cm from the electrical center. If trace shift exceeds this limit, check the balance of the distributed amplifier as described in the following paragraphs.

d. Distributed Amplifier Balance

Position the free-running trace at the electrical center of the crt beam. Short together the two common grid lines of the distributed amplifier and note the trace shift from electrical center. The shift must not exceed 2 mm. If the trace shifts more than this, the balance of each pair of tubes should be checked. Remove the shorting strap before checking the pair balance.

Each pair of tubes is checked by separately biasing the pair to cutoff and noting the amount of trace shift. This is done by raising the cathode voltage (pin 2) to +225 volts. Bias voltage may be applied with a voltmeter lead by connecting to the +225-volt supply. Trace shift caused by any pair should not exceed 2 mm.

It is usually most convenient to start at one end of the distributed amplifier and record the direction and amount of trace deflection caused by each pair of tubes. Replace any pair producing more than 2 mm trace shift. Check the grid bias again if tubes are replaced. After checking all six pairs of tubes and replacing where necessary, recheck the total balance of the distributed amplifier.

If there is still more than 2 mm total trace shift, balance may be obtained by exchanging the two tubes of a pair. Switching the tubes reverses the direction of the trace shift produced by the pair. To produce a balance in the distributed amplifier, the total deflection in one direction must equal that in the other direction. Inspection of the record of the amount and direction of deflection caused by each pair will show which pair should have their tubes interchanged to produce a balanced condition.

Check the total balance of the distributed amplifier again after exchanging tubes.

See 5-1-1

e. Driver Stage Balance

Position a free-running trace at the electrical center of the crt beam. Short together the two grids (pin 7) of V1033 and V1043 to check the balance of the input driver stage. The trace should not shift more than 5 mm. If shift exceeds this amount, replace the driver tubes to achieve balance.

f. Input Amplifier Balance

With the distributed amplifier and driver stage tubes balanced as described above, again check the overall balance of the Vertical Amplifier. If trace shift is now more than 1 cm, the unbalance is in the input amplifier tubes, V1014 and V1024. Try interchanging the two tubes. If this does not produce overall balance, replace the input amplifier tubes with new aged-and-matched tubes, as listed in the Parts List.

g. Vertical Gain and Balance

If tubes have been replaced in the Vertical Amplifier, check the gain and dc shift compensation as given earlier in the calibration procedure.

36. Adjust High-Frequency Compensation

The procedures for adjusting the high-frequency controls are the same for both beams; therefore they will be described for only one of the beams. It is recommended that you read through the entire procedure before attempting to make any adjustments.

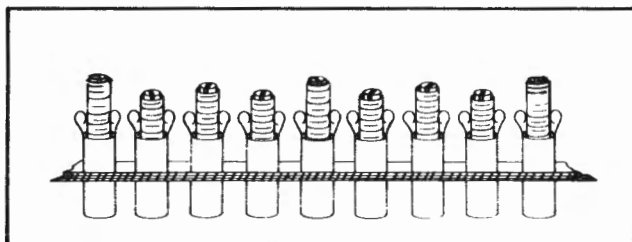


Fig. 6-23. Normal adjustment pattern of trimmer capacitors in the delay line section at the rear of the instrument. Trimmer capacitors in the section near the crt should be fairly even (see text).

As a rule, the inductors and capacitors will not require pre-setting unless they have been badly misadjusted. To check the approximate physical positions of the inductor and capacitor cores (slugs), compare the controls of one beam to those of the other. Figs. 6-23 and 6-24 show the approximate physical settings of the slugs when the instrument is properly calibrated.

The capacitors in the long section of the delay line at the rear of the instrument generally follow a wavy pattern as shown in the illustration. However, those in the delay line section nearer the crt should appear fairly even. The 3 or 4 trimmer capacitors nearest the crt may be somewhat irregular. No slug should extend as far out as the delay line shield, nor completely into the body of the capacitor.

The positions of the slugs in the inductors may be seen by shining a light through the coil forms. Since the inductors operate in pairs, both slugs in a pair of inductors should be set at approximately the same depth in the coil forms.

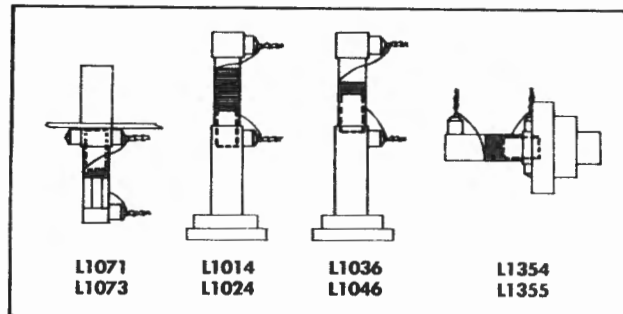


Fig. 6-24. Approximate slug positions in the high-frequency variable inductors.

If the slug positions in the inductors are approximately correct, do not adjust them at this time. However, if it appears that the inductors have been misadjusted by a large amount, it is recommended that the slugs be set as illustrated.

If the inductors are adjusted as a result of this preliminary check, recheck the characteristics of the displayed pulse. There will now probably be some rolloff or overshoot. Rolloff can be corrected later, but overshoot should be removed before making any other compensation adjustments. Turn each of the slugs in inductors L1014 and L1024 clockwise by equal small amounts until the overshoot is removed.

Adjustment of the high-frequency controls should be performed in the following order:

1. Remove major irregularities from the top of the displayed pulse with the delay line adjustments. The adjustable portion of the pulse top should be level, fairly regular and should match the height of the reference level. (Use a Type 107 Square-Wave Generator and a Type K Plug-In Unit.)

2. Adjust the rise and front corner of the pulse with the inductors and last four capacitors. The rise should be fast and the corner should be square with no overshoot or irregularities following the front corner. (Adjust only with a Type P or Type TU-7 Plug-In Test Unit.)

3. Remove minor irregularities from the top of the pulse by "touching up" the adjustment of the delay line capacitors. The pulse top should be smooth and continuous with no irregularities exceeding one tracewidth. (Adjust with the Type 107 and the Type K).

Since the tubes in the Vertical Amplifier can affect all of the above characteristics, the tubes must be checked before making any adjustments except minor touching up of the delay line capacitors.

a. Remove Major Irregularities

The purpose of this step is to produce a level top on the waveform without introducing more than a minimum number of minor irregularities. The first part of the pulse top must be raised, lowered or smoothed as required to match the reference level. When the level and slope are correct, the pulse top will appear as a straight line. It is very easy to introduce minor irregularities to the display while attempting to adjust the level of the pulse top. These irregularities can be kept at a minimum by following the procedure suggested here.

With the Type K Unit installed in the plug-in compartment of the beam being calibrated, set up the display as indicated in the transient response check (step 33), and obtain a display similar to Fig. 6-18.

Turning the capacitor slug clockwise will tend to lower the affected portion of the display, and turning it counterclockwise will raise the level. If the entire adjustable portion of the displayed pulse needs to be raised or lowered, turn each trimmer capacitor in the delay line by a small equal amount. Do not watch the crt display while adjusting these controls, but rather watch the adjustment tool to see that each capacitor is turned an equal amount. Then observe the display to see what further adjustments are required. If each capacitor is turned an equal amount without observing the display, minor irregularities will be minimized.

If only certain segments of the pulse top require adjustment to the proper level, it is usually best to begin with the portions that are farthest from the correct level. These adjustments are also made by adjusting the capacitors without watching the crt display. The portion of the display affected by any particular capacitor can be located by turning the capacitor slightly while watching the crt display, then returning it to the original position. Locate the group of capacitors affecting the portion of the display to be adjusted, then turn each capacitor in the group by a small amount.

After adjusting one segment of the delay line, check the display again. Continue adjusting small groups of capacitors by this procedure to smooth and partially correct the level of the display. Periodically switch the TIME/CM to 1 and 2 μ SEC to check the level of the display. This method of adjusting each segment by a small amount will have the effect of gradually smoothing and straightening the top of the pulse. It is not necessary at this time to remove minor irregularities. When the top of the pulse appears to be reasonably straight and level, the display will provide a satisfactory starting point for the risetime and smoothing adjustments that follow.

b. Adjust Rise and Front Corner

When the level of the pulse top is correct, recheck the risetime of the system using the Type K and Type 107 Square-Wave Generator as described previously in the transient response check. If the risetime is now less than 12 nsec with no overshoot, no adjustments should be made of the high-frequency inductors. Remove minor irregularities in the pulse top as described below, if necessary.

If the risetime is longer than 12 nsec or if the front corner has overshoot or appears to need adjustment, use a Type P or Type TU-7 Plug-In Test Unit to adjust the high-frequency inductors. A Type K should not be used for these adjustments because the performance of the system would then depend on the particular combination of the plug-in unit and the beam that is calibrated with that plug-in. The Type P and Type TU-7 units contain pulse generators with fast-rise pulses of known characteristics.

The high-frequency compensation inductors consist of three pairs of variable coils shown in Fig. 6-20. Although all three pairs affect the pulse appearance, the greatest effect is produced by L1014 and L1024 in the input amplifier stage of the Vertical Amplifier. Generally these two coils will provide sufficient adjustment of the rise and corner, if the slug positions in the other inductors are approximately correct. How-

ever, if the risetime is not short enough after adjusting this pair, the inductors at the crt end of the delay line and those in the driver stage of the Vertical Amplifier can also be adjusted.

With the Type P or Type TU-7 Test Unit in the plug-in compartment of the beam under calibration, allow the instrument to warm up for about 10 minutes. Be sure the plug-in unit is secured tightly. Set the HORIZ. DISPLAY switch to Time Base A (or B) X1, and the TIME/CM switch to .1 μ SEC. Adjust the pulse display for 3 cm of vertical deflection. Use a dim trace and the sharpest possible focus for viewing the pulse display.

The portion of the pulse top immediately following the corner is controlled by both the high-frequency inductors and some of the delay line capacitors. Due to this interaction, it is usually necessary to readjust the four delay line capacitors nearest the crt after each adjustment of the inductors, in order to determine the correct inductor settings. However, do not adjust any other delay line capacitors at this time. Minor irregularities in the pulse top will be removed later using the Type K unit.

If the risetime is too long and the front corner has rolloff, increase the inductance of L1014 and L1024 by turning the slugs equal small amounts in the counterclockwise direction. This may produce some overshoot which can be removed by adjusting the four capacitors nearest the crt. Continue alternately adjusting the two inductors and the four capacitors until a slight overshoot appears that cannot be removed with the capacitors. Then back off the inductors slightly until the overshoot is removed and readjust the capacitors for a straight line out to the corner of the pulse. Set the TIME/CM switch to 2 μ SEC to be sure the level of the front corner is correct, then switch back to .1 μ SEC.

If the front corner of the pulse has minor overshoot that cannot be removed with the four capacitors nearest the crt, it will be necessary to decrease the inductance of L1014 and L1024. Turn the slug in each of these inductors clockwise by a small amount, then recheck the crt display and adjust the four capacitors as before. Repeat the small adjustment of the inductors and capacitors if necessary.

After adjusting the input amplifier inductors, recheck the risetime. If it is still too long, the other inductors may be adjusted. The inductors at the crt end of the delay line (L1354-L1355) are adjusted in approximately the same manner as the previous adjustments, but will not have as much effect on the crt display. (These inductors compensate primarily for capacitance of the crt deflection plates.)

If you adjust L1036 and L1046 in the driver stage of the Vertical Amplifier, set them to provide the squarest corner without causing irregularities following the front corner. They probably will not produce overshoot when they are adjusted.

After completion of the inductor adjustments, check the displayed pulse again for risetime and irregularities.

c. Remove Minor Irregularities

Since the adjustments for a level pulse top and short risetime often introduce small irregularities, the removal of all minor irregularities should be left until the other characteristics are satisfactory. The trimmer capacitors in the delay line are used for removing or minimizing these irregularities. Touching up the delay line capacitors will not affect the pulse risetime.

Install the Type K in the plug-in compartment of the beam under calibration. Apply the fast-rise square-wave signal from the Type 107 Square-Wave Generator through a 50-ohm termination to the INPUT of the Type K Plug-In Unit. Set the TIME/CM switch to .2 μ SEC, the HORIZ. DISPLAY switch to Time Base A (or B) X1, and set the SLOPE switch to —. (Minus slope must be used to eliminate triggering irregularities from the top of the displayed pulse.)

Adjustment of the delay line should begin at the termination network and progress toward the crt end of the delay line. In this way the lower frequency controls affecting the display adjacent to the reference level will be adjusted first, with subsequent adjustment of the higher frequency controls. While adjusting these capacitors to remove minor irregularities, observe the effects on the crt display. The adjustment tool that is used to remove minor irregularities should not introduce extra capacitance to the circuit. The tool illustrated in Fig. 6-1 is designed for low capacitance. It is usually helpful to subdivide the delay line into overlapping groups of about 10 capacitors each. Include the last two or three capacitors of one group as part of the next group. This overlapping will result in a smoother display at the end of the procedure. Since there is extensive interaction between the controls, it will be necessary to underadjust each capacitor at first. Later adjustment of adjacent capacitors will change the apparent adjustment of any particular capacitor. After adjusting each group of ten capacitors, turn the TIME/CM switch to the 2 μ SEC position momentarily to recheck the level of the pulse top. If necessary, readjust the delay line to restore the proper display level.

During these adjustments, it may appear that an irregularity tends to move sideways on the display as one of the capacitors is adjusted. If this occurs, set the capacitor for minimum distortion (the smoothest curve) and postpone further adjustment until after other capacitors in the group have been adjusted.

When the front corner of the pulse is reached, the capacitors should be adjusted for the squarest corner without overshoot. Do not readjust the high-frequency inductors.

After the minor irregularities in the pulse top have been minimized, check the pulse characteristics again with those in Figures 6-17 through 6-19. When all of the high-frequency compensation controls have been adjusted correctly, the top of the pulse should appear as a straight smooth line regardless of the position of the TIME/CM switch.

37. Check Vertical Passband

Install the Type K Plug-In Unit in the Upper Beam compartment and the other vertical plug-in unit in the Lower Beam compartment. Allow 10 to 15 minutes warm-up. Set front-panel controls as follows:

Upper Beam	
HORIZ. DISPLAY	Time Base A X1
Lower Beam	
HORIZ. DISPLAY	Time Base B X1
Time Base A and Time Base B	
SWEEP FUNCTION	AUTO BASELINE
LEVEL	Clockwise
TIME/CM	1 mSEC
SOURCE	UPPER BEAM

Type K (Upper Beam)

VOLTS/CM	.05
VARIABLE	CALIBRATED
AC-DC	DC

a. Upper Beam

Install a 50-ohm termination on the INPUT connector of the Type K. Set the Type 190B Constant-Amplitude Signal Generator for an output frequency of 50 kc and an amplitude of 0.2 volts and connect the output to the 50-ohm termination (using an adapter if necessary). Center the signal display on the upper horizontal centerline and adjust the FOCUS control for the sharpest focus of the edges of the display.

Adjust the signal generator to produce a vertical deflection of 3 cm on the crt screen. Increase the signal frequency to approximately 30 mc. Observe the crt display and adjust the frequency to produce exactly 2.1 cm of vertical deflection. This is the upper-limit 3-db down point. The signal frequency should now be at least 30 mc.

The passband of the vertical system is closely related to the risetime. In general, if the risetime with the Type K Unit is less than 12 nsec, the upper-limit 3-db down point will be greater than 30 mc. If the passband does not meet specifications, the indication is that the inductors and the capacitors affecting the rise and front corner require adjustment.

b. Lower Beam

Turn off the instrument, exchange the plug-in units and turn on the power again. Apply the sine-wave signal from the signal generator to the Type K Unit in the Lower Beam compartment. After a brief warm-up period, check the passband of the Lower Beam vertical circuitry, with the display centered about the lower horizontal centerline.

Remove the input signal and the termination at the end of this step.

38. Check Front-Panel Outputs

Six outputs are provided from the oscilloscope and time-base units: Amplitude Calibrator; Delayed Trigger from Time Base A; and Sawtooth and + Gate signals from each time-base unit. (The calibrator has been checked previously).

Reset the following controls:

Time Base A	
LEVEL	Clockwise
TIME/CM	10 μ SEC
Upper Beam Vertical Plug-In	
Deflection Factor	5 v/cm (cal.)
Input Coupling	DC

a. Delayed Trigger from Time Base A

Connect a coaxial cable from the DLY'D TRIG. OUT connector to the INPUT of the Upper Beam plug-in unit. Trigger the display with the Time Base A LEVEL control. Check for Delayed Pulse amplitude between 5 and 10 volts. The Delayed Trigger pulse should move smoothly across the screen as the DELAYED TRIGGER 1-10 MULTIPLIER control is turned.

Remove the coaxial cable.

b. 'A' Sawtooth and +Gate

Set the VOLTS/CM switch on the Type K to 5 and set the Time Base B TIME/CM switch to 50 μ SEC. Connect the 10X probe to the INPUT of the Type K and connect the probe tip to the Time Base A SAWTOOTH output. Trigger the display and check the sawtooth waveform for an amplitude between 130 and 170 volts.

Move the probe from the SAWTOOTH output to the +GATE output on the Time Base A unit. Set the VOLTS/CM switch to 1. Check the +Gate waveform for an amplitude between 20 and 35 volts.

Remove the probe.

c. 'B' Sawtooth and +Gate

Reset the following controls:

Time Base A

TIME/CM 2 mSEC

Time Base B

LEVEL Clockwise

TIME/CM .5 mSEC

Upper Beam Plug-In Unit

Deflection Factor 5 v/cm (cal.)

Input Coupling DC

Connect the 10X probe to the INPUT connector on the Upper Beam vertical plug-in unit and the probe tip to the Time Base B SAWTOOTH output. Trigger the Upper Beam display with the Time Base A LEVEL control. Check the Time Base B sawtooth waveform for an amplitude between 130 and 170 volts.

Move the probe to the Time Base B +GATE output and check for an amplitude between 20 and 35 volts. Remove the probe.

SECTION 7

PARTS LIST and DIAGRAMS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix Field Office.



Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix Field Office will contact you concerning any change in part number.

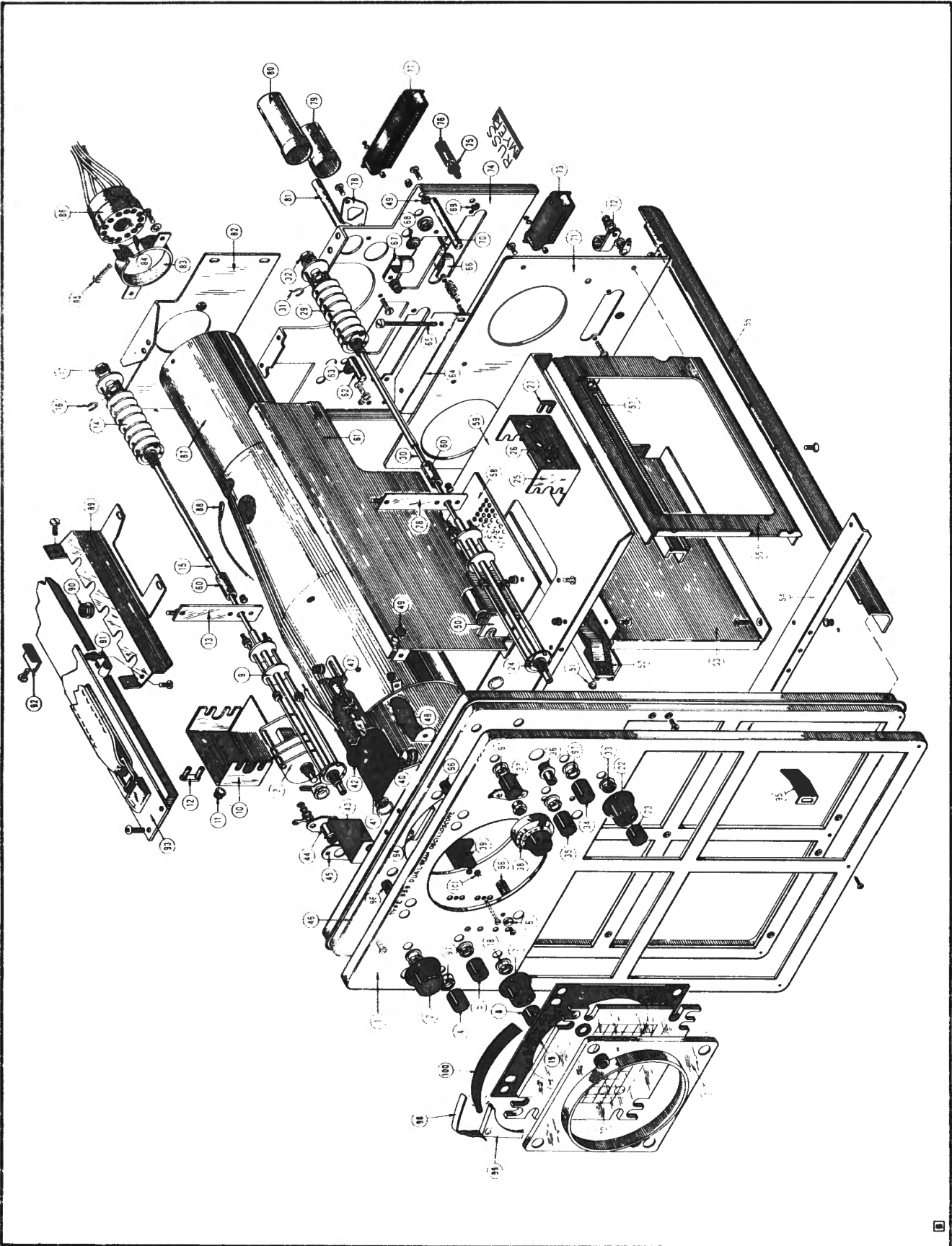
ABBREVIATIONS AND SYMBOLS

a or amp	amperes	mm	millimeter
BHS	binding head steel	meg or M	megohms or mega (10 ⁶)
C	carbon	met.	metal
cer	ceramic	μ	micro, or 10 ⁻⁶
cm	centimeter	n	nano, or 10 ⁻⁹
comp	composition	Ω	ohm
cps	cycles per second	OD	outside diameter
crt	cathode-ray tube	OHS	oval head steel
CSK	counter sunk	p	pico, or 10 ⁻¹²
dia	diameter	PHS	pan head steel
div	division	piv	peak inverse voltage
EMC	electrolytic, metal cased	plstc	plastic
EMT	electrolytic, metal tubular	PMC	paper, metal cased
ext	external	poly	polystyrene
f	farad	Prec	precision
F & I	focus and intensity	PT	paper tubular
FHS	flat head steel	PTM	paper or plastic, tubular, molded
Fil HS	fillister head steel	RHS	round head steel
g or G	giga, or 10 ⁹	rms	root mean square
Ge	germanium	sec	second
GMV	guaranteed minimum value	Si	silicon
h	henry	S/N	serial number
hex	hexagonal	t or T	tera, or 10 ¹²
HHS	hex head steel	TD	toroid
HSS	hex socket steel	THS	truss head steel
HV	high voltage	tub.	tubular
ID	inside diameter	v or V	volt
incd	incandescent	Var	variable
int	internal	w	watt
k or K	kilohms or kilo (10 ³)	w/	with
kc	kilocycle	w/o	without
m	milli, or 10 ⁻³	WW	wire-wound
mc	megacycle		

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.
	Front-panel adjustment or connector.

EXPLODED VIEW-FRONT GROUP



EXPLODED VIEW-FRONT GROUP

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	333-0476-00 ----- 213-0088-00			1 - 5	PANEL, front Mounting Hardware: (not included) SCREW, thread forming 4-40 x 1/4 inch PHS phillips
2	366-0060-00 366-0115-00 ----- 213-0004-00	7000 10870	10869	1 1 -	KNOB AMPLITUDE CALIBRATOR, large black KNOB, AMPLITUDE CALIBRATOR, large charcoal Includes:
3	262-0212-00 ----- 260-0253-00 ----- 210-0413-00 210-0840-00 210-0013-00 210-0207-00			1 1 - 1 - 1 1 1 1	SCREW, set, 6-32 x 3/16 inch HSS SWITCH, AMPLITUDE CALIBRATOR, wired Includes: SWITCH, unwired Mounting Hardware: (not included) NUT, hex, 3/8-32 x 1/2 inch WASHER, .390 ID x 3/16 inch OD LOCKWASHER, internal, 3/8 x 17/16 inch LUG, solder, 3/8 inch
4	366-0033-00 366-0148-00 ----- 213-0004-00	7000 10870	10869	1 1 -	KNOB, FOCUS, UPPER BEAM, small black KNOB, FOCUS, UPPER BEAM, small charcoal Includes:
5	366-0033-00 366-0148-00 ----- 213-0004-00	7000 10870	10869	1 1 -	SCREW, set, 6-32 x 3/16 inch HSS KNOB, INTENSITY, UPPER BEAM, small black KNOB, INTENSITY, UPPER BEAM, small charcoal Includes:
6	401-0004-00 ----- 213-0012-00	7000	8999X	1 -	SCREW, set, 6-32 x 3/16 inch HSS CAM, nylon Mounting Hardware: (not included)
7	366-0040-00 366-0160-00 ----- 213-0004-00	7000 10870	10869	1 1 -	SCREW, thread cutting, 4-40 x 3/8 inch FHS phillips KNOB, HORIZ. DISPLAY, UPPER BEAM, black KNOB, HORIZ. DISPLAY, UPPER BEAM, charcoal Includes:
8	366-0031-00 ----- 213-0004-00			1 -	SCREW, set, 6-32 x 3/16 inch HSS KNOB, HORIZ. POSITION, UPPER BEAM, red Includes:
9	262-0213-00 ----- 260-0269-00			1 -	SCREW, set, 6-32 x 3/16 inch HSS SWITCH, HORIZ. DISPLAY, UPPER BEAM, front, wired Includes:
10	406-0457-00			1	SWITCH, unwired
11	----- 210-0583-00 210-0046-00 214-0153-00			1 1 1	BRACKET, switch Mounting Hardware For Miniature Pot: NUT, hex, 1/4-32 x 5/16 inch LOCKWASHER, internal, .400 OD x .261 inch ID
12	406-0464-00			1	FASTENER, snap, double pronged
13	----- 210-0406-00 210-0004-00			1 2 2	BRACKET, support Mounting Hardware: (not included) NUT, hex, 4-40 x 3/16 inch LOCKWASHER, internal, #4

EXPLODED VIEW-FRONT GROUP (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
14	262-0613-00			1	SWITCH, HORIZ. DISPLAY, UPPER BEAM, rear, wired
	- - - - -			-	Includes:
	260-0270-00			1	SWITCH, unwired
15	384-0182-00			1	ROD, extension
16	376-0014-00			1	COUPLING, pot
17	- - - - -			-	Mounting Hardware For Pot:
	210-0413-00			2	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
	210-0012-00			1	LOCKWASHER, internal, $\frac{3}{8}$ x $\frac{1}{2}$ inch
18	- - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
	210-0840-00			1	WASHER, .390 ID x $\frac{9}{16}$ inch OD
	210-0012-00			1	LOCKWASHER, internal, $\frac{3}{8}$ x $\frac{1}{2}$ inch
	210-0406-00			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch
	210-0801-00			1	WASHER, 5S x $\frac{9}{32}$ inch
	210-0004-00			1	LOCKWASHER, internal, #4
19	337-0187-00	7000	8999X	1	SHIELD, graticule light
20	331-0045-00	7000	8999X	1	GRATICULE, 5 inch
21	200-0382-00			1	COVER, graticule
	- - - - -			-	Includes:
	354-0116-00			1	RING, ornamental
	- - - - -			-	Mounting Hardware: (not included)
	210-0424-00			4	NUT, knurled, graticule, $\frac{3}{8}$ -24 x $\frac{9}{16}$ inch
	210-0816-00			4	WASHER, rubber
22	366-0040-00	7000	10869	1	KNOB, HORIZ. DISPLAY, LOWER BEAM, black
	366-0160-00	10870		1	KNOB, HORIZ. DISPLAY, LOWER BEAM, charcoal
	- - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
23	366-0031-00			1	KNOB, HORIZ. POSITION, LOWER BEAM, red
	- - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
24	262-0214-00			1	SWITCH, HORIZ. DISPLAY, LOWER BEAM, front, wired
	- - - - -			-	Includes:
	260-0269-00			1	SWITCH, unwired
25	406-0458-00			1	BRACKET, switch
26	- - - - -			-	Mounting Hardware For Miniature Pot:
	210-0583-00			1	NUT, hex, $\frac{1}{4}$ -32 x $\frac{5}{16}$ inch
	210-0046-00			1	LOCKWASHER, internal, .400 OD x .261 inch ID
27	214-0153-00			1	FASTENER, snap, double pronged
28	406-0464-00			1	BRACKET, support
	- - - - -			-	Mounting Hardware:
	210-0406-00			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch
	210-0004-00			2	LOCKWASHER, internal, #4

EXPLODED VIEW-FRONT GROUP (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
29	262-0614-00			1	SWITCH, HORIZ. DISPLAY, LOWER BEAM, rear, wired
	- - - - -			-	Includes:
	260-0270-00			1	SWITCH, unwired
30	384-0182-00			1	ROD, extension
31	376-0014-00			1	COUPLING, pot
32	- - - - -			-	Mounting Hardware For Pot:
	210-0413-00			2	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
	210-0012-00			1	LOCKWASHER, internal, $\frac{3}{8}$ x $\frac{1}{2}$ inch
33	- - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
	210-0840-00			1	WASHER, .390 ID x $\frac{9}{16}$ inch OD
	210-0012-00			1	LOCKWASHER, internal, $\frac{3}{8}$ x $\frac{1}{2}$ inch
	210-0406-00			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch
	210-0801-00			1	WASHER, 5S x $\frac{9}{32}$ inch
	210-0004-00			1	LOCKWASHER, internal, #4
34	366-0033-00	7000	10869	1	KNOB, INTENSITY, LOWER BEAM, small black
	366-0148-00	10870		1	KNOB, INTENSITY, LOWER BEAM, small charcoal
	- - - - -			-	Includes:
	213-004-00			1	SCREW, set 6-32 x $\frac{3}{16}$ inch HSS
35	366-0033-00	7000	10869	1	KNOB, FOCUS, LOWER BEAM, small black
	366-0148-00			1	KNOB, FOCUS, LOWER BEAM, small charcoal
	- - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
36	131-0126-00			1	CONNECTOR, chassis mount, BNC, female
37	366-0033-00	7000	10869	1	KNOB, SCALE ILLUM., small black
	366-0148-00	10870		1	KNOB, SCALE ILLUM., small charcoal
	- - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
38	331-0022-00	7000	10869	1	DIAL, black
	331-0091-00	10870		1	DIAL, charcoal
	- - - - -			-	Includes:
	- - - - -			1	NUT, pot mounting
	- - - - -			1	LUG, pot index
39	352-0006-00	7000	11279	4	HOLDER, neon, double
	352-0064-00	11280		4	HOLDER, neon, double
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0031-00	7000	11279	1	SCREW, 4-40 x 1 inch FHS
	211-0109-00	11280		1	SCREW, 4-40 x $\frac{7}{8}$ inch, 100°, csk, FHS
	210-0406-00			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch
40	134-0031-00			1	PLUG, CRT contact
41	200-0112-00			1	COVER, CRT anode, assembly
	- - - - -			-	Consisting Of:
	200-0111-00			1	COVER, CRT anode
	386-0647-00			1	PLATE, CRT anode
42	131-0107-00			1	CONNECTOR, cable, anode assembly
	- - - - -			-	Includes:
	131-0073-00			1	CONNECTOR, CRT brush
	200-0110-00			1	CAP, CRT anode
42	337-0304-00			1	SHIELD, focus and intensity, left
44	131-0279-00			1	CONNECTOR, chassis mount, BNC, female
	- - - - -			-	Mounting Hardware: (not included)
	211-0025-00			2	SCREW, 4-40 x $\frac{3}{8}$ inch FHS
	210-0224-00			1	LUG, solder, #10, non-locking
	210-0812-00			2	WASHER, rubber
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch
45	406-0244-00			1	BRACKET, nylon, insulator
	210-0961-00	7000	7588X	1	WASHER, plastic, $\frac{3}{8}$ ID x $\frac{13}{16}$ inch OD

EXPLODED VIEW-FRONT GROUP (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
46	386-0896-00	7000	8999X	1	PLATE, front subpanel
	- - - - -			-	Includes:
	354-0076-00			1	RING, ornamental
47	136-0035-00			2	SOCKET, graticule light
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0534-00			2	SCREW, 6-32 x $\frac{5}{16}$ inch PHS with lockwasher
	210-0803-00			2	WASHER, 6L x $\frac{3}{8}$ inch
	210-0457-00			2	NUT, keps, 6-32 x $\frac{5}{16}$ inch
48	406-0239-00			4	BRACKET, CRT spring
49	348-0002-00			3	GROMMET, $\frac{1}{4}$ inch
50	337-0305-00			1	SHIELD, focus and intensity, right
51	348-0023-00			8	FOOT, white nylon
52	122-0083-00			2	ANGLE, brace, left
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0011-00			2	SCREW, 4-40 x $\frac{5}{16}$ inch BHS
	211-0038-00			2	SCREW, 4-40 x $\frac{5}{16}$ inch FHS phillips
53	386-0611-00			2	PLATE, plug-in housing, CRT left and right
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0538-00			3	SCREW, 6-32 x $\frac{5}{16}$ inch FHS phillips
	210-0006-00			3	LOCKWASHER, internal, #6
	210-0407-00			3	NUT, hex, 6-32 x $\frac{1}{4}$ inch
54	386-0610-00			1	PLATE, plug-in housing, bottom
	- - - - -			-	Mounting Hardware: (not included)
	211-0559-00			4	SCREW, 6-32 x $\frac{3}{8}$ inch FHS phillips
	210-0457-00			4	NUT, keps, 6-32 x $\frac{5}{16}$ inch
55	386-0614-00			2	PLATE, plug-in housing, outside
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0538-00			3	SCREW, 6-32 x $\frac{5}{16}$ inch FHS phillips
	210-0006-00			3	LOCKWASHER, internal, #6
	210-0407-00			3	NUT, hex, 6-32 x $\frac{1}{4}$ inch
56	122-0072-00			2	ANGLE, frame, bottom
	- - - - -			-	Mounting Hardware For Each: (not included)
	212-0039-00			4	SCREW, 8-32 x $\frac{3}{8}$ inch THS phillips
	210-0458-00			4	NUT, keps, 8-32 x $\frac{1}{12}$ inch
57	122-0082-00			2	ANGLE, brace, right
	- - - - -			-	Mounting Hardware For Each (not included)
	211-0011-00			2	SCREW, 4-40 x $\frac{5}{16}$ inch BHS
	211-0038-00			2	SCREW, 4-40 x $\frac{5}{16}$ inch FHS phillips
58	386-0752-00			1	PLATE, plug-in housing, top shield
	- - - - -			-	Mounting Hardware: (not included)
	211-0008-00			4	SCREW, 4-40 x $\frac{1}{4}$ inch BHS
	210-0004-00			4	LOCKWASHER, internal, #4
	210-0406-00			4	NUT, hex, 4-40 x $\frac{3}{16}$ inch
59	386-0655-00			1	PLATE, plug-in housing, top
	- - - - -			-	Mounting Hardware: (not included)
	211-0559-00			3	SCREW, 6-32 x $\frac{3}{8}$ inch FHS phillips
	210-0457-00			3	NUT, keps, 6-32 x $\frac{5}{16}$ inch

EXPLODED VIEW-FRONT GROUP (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
60	376-0007-00			2	COUPLING
	- - - - -			-	Each Includes:
	213-0005-00			2	SCREW, set, 8-32 x 1/8 inch HSS
61	386-0900-00			1	PLATE, time base divider
	- - - - -			-	Mounting Hardware: (not included)
	211-0559-00			1	SCREW, 6-32 x 3/8 inch FHS phillips
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
62	385-0135-00			1	ROD, delrin
	- - - - -			-	Mounting Hardware: (not included)
	213-0041-00			1	SCREW, thread cutting, 6-32 x 3/8 inch THS phillips
63	348-0003-00			1	GROMMET, 5/16 inch
64	406-0292-00			1	BRACKET, transformer support
	- - - - -			-	Mounting Hardware: (not included)
	211-0511-00			2	SCREW, 6-32 x 1/2 inch BHS
	210-0803-00			4	WASHER, 6L x 3/8 inch
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
65	- - - - -			-	Mounting Hardware For Transformer:
	212-0017-00			4	SCREW, 8-32 x 5 inches HHS
	210-0008-00			8	LOCKWASHER, internal, #8
	210-0804-00			2	WASHER, 8S x 3/8 inch
	210-0409-00			4	NUT, hex, 8-32 x 5/16 inch
66	343-0005-00			2	CLAMP, cable, 7/16 inch
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0513-00			1	SCREW, 6-32 x 5/8 inch BHS
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
	210-0803-00			2	WASHER, 6L x 3/8 inch
67	343-0004-00			1	CLAMP, cable, 5/16 inch
	- - - - -			-	Mounting Hardware: (not included)
	211-0511-00			1	SCREW, 6-32 x 1/2 inch BHS
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0407-00			1	NUT, hex, 6-32 x 1/4 inch
68	348-0005-00			1	GROMMET, 1/2 inch
69	354-0048-00			2	RING, securing
70	385-0137-00			1	ROD, delrin
	- - - - -			-	Mounting Hardware: (not included)
	213-0041-00			1	SCREW, thread cutting, 6-32 x 3/8 inch THS phillips
71	386-0654-00			1	PLATE, plug-in housing, back
	- - - - -			-	Mounting Hardware: (not included)
	211-0507-00			6	SCREW, 6-32 x 5/16 inch BHS
	210-0202-00			2	LUG, solder, SE6
	210-0006-00			6	LOCKWASHER, internal, #6
	210-0407-00			6	NUT, hex, 6-32 x 1/4 inch
	211-0522-00			2	SCREW, 6-32 x 5/8 inch FHS phillips
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
72	343-0006-00			2	CLAMP, cable, 1/2 inch
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0513-00			1	SCREW, 6-32 x 3/8 inch BHS
	210-0202-00			1	LUG, solder, SE6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
	210-0803-00			2	WASHER, 6L x 3/8 inch
	210-0006-00			1	LOCKWASHER, internal, #6

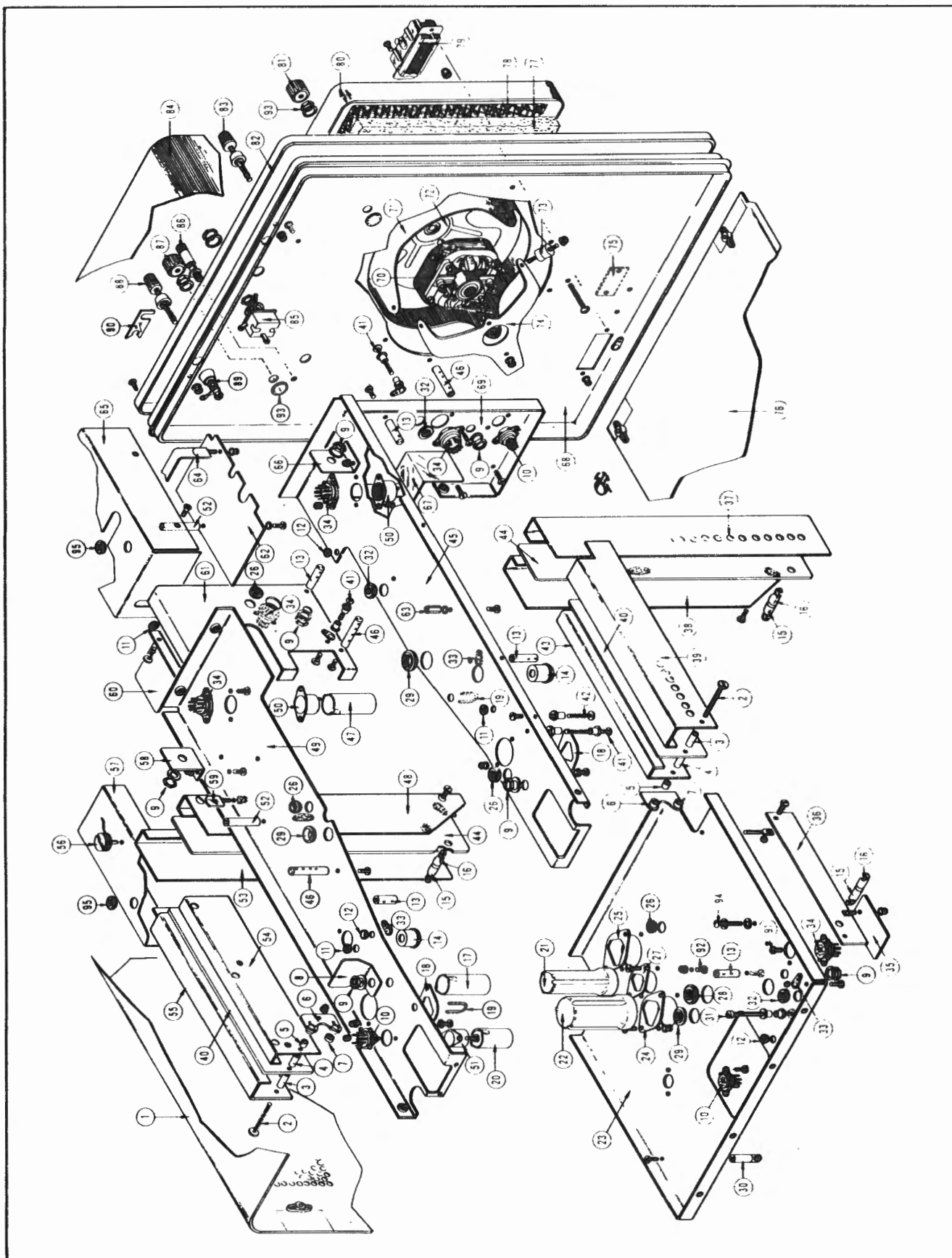
EXPLODED VIEW-FRONT GROUP (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
73	131-0018-00	9000 10970	10969	2	CONNECTOR, chassis mount, 16 contact
-	-			-	Mounting Hardware For Each: (not included)
-	211-0016-00			2	SCREW, 4-40 x $\frac{5}{8}$ inch RHS
-	166-0107-00			2	TUBE, spacing, $\frac{7}{32}$ inch
-	166-0030-00			2	TUBE, spacing, $\frac{3}{16}$ inch
-	210-0004-00			2	LOCKWASHER, internal, #4
-	210-0406-00			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch
74	386-0895-00			1	PLATE, time base, rear
-	-			-	Mounting Hardware: (not included)
-	211-0507-00			4	SCREW, 6-32 x $\frac{5}{16}$ inch BHS
-	210-0457-00			4	NUT, keps, 6-32 x $\frac{5}{16}$ inch
75	210-0805-00	9000 10970	10969	2	WASHER, 10S x $\frac{7}{16}$ inch
76	214-0074-00			2	BOLT, captive
77	131-0097-00			2	CONNECTOR, chassis mount, 32 contact
-	-			-	Mounting Hardware For Each: (not included)
-	355-0050-00			2	STUD, 4-40 x $\frac{13}{16}$ inch long
-	214-0123-00			2	SPRING, wire, $\frac{7}{32}$ inch long
-	210-0801-00			2	WASHER, 5S x $\frac{9}{32}$ inch
-	210-0004-00			2	LOCKWASHER, internal, #4
-	210-0406-00			4	NUT, hex, 4-40 x $\frac{3}{16}$ inch
78	386-0252-00			2	PLATE, fiber, small capacitor
-	-			-	Mounting Hardware For Each: (not included)
-	211-0534-00			2	SCREW, 6-32 x $\frac{5}{16}$ inch PHS with lockwasher
-	210-0006-00			2	LOCKWASHER, internal, #6
-	210-0407-00			2	NUT, hex, 6-32 x $\frac{1}{4}$ inch
79	200-0256-00			1	COVER, capacitor
80	200-0257-00	9000 10970	10969	1	COVER, capacitor
81	384-0553-00			1	ROD, post, nylon
-	-			-	Mounting Hardware: (not included)
-	211-0507-00			1	SCREW, 6-32 x $\frac{5}{16}$ inch BHS
82	406-0455-00			1	BRACKET, CRT support
-	-			-	Mounting Hardware: (not included)
-	211-0507-00			4	SCREW, 6-32 x $\frac{5}{16}$ inch BHS
-	210-0803-00			4	WASHER, 6L x $\frac{3}{8}$ inch
-	210-0457-00			4	NUT, keps, 6-32 x $\frac{5}{16}$ inch
83	343-0047-00			1	CLAMP, CRT
-	-			-	Mounting Hardware: (not included)
-	213-0049-00			2	SCREW, 6-32 x $\frac{5}{16}$ inch HHS
-	210-0949-00			2	WASHER, $\frac{9}{64}$ ID x $\frac{1}{2}$ inch OD
84	210-0501-00			1	NUT, square, 10-32 x $\frac{3}{8}$ inch
85	212-0548-00			1	SCREW, 10-32 x $\frac{7}{8}$ inch RHS
86	179-0870-00	9000 10970	10969	1	CABLE HARNESS, CRT socket
-	-			-	Includes:
-	136-0019-00			1	SOCKET, raw, STM14
-	211-0017-00			2	SCREW, 4-40 x $\frac{3}{4}$ inch, RHS
-	210-0586-00			2	NUT, keps, 4-40 x $\frac{1}{4}$ inch
87	337-0282-00			1	SHIELD, CRT
-	-			-	Mounting Hardware: (not included)
-	211-0538-00			4	SCREW, 6-32 x $\frac{5}{16}$ inch FHS phillips
-	211-0534-00			2	SCREW, 6-32 x $\frac{5}{16}$ inch PHS with lockwasher
-	210-0803-00			2	WASHER, 6L x $\frac{3}{8}$ inch
-	210-0457-00			6	NUT, keps, 6-32 x $\frac{5}{16}$ inch

EXPLODED VIEW-FRONT GROUP (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
88	175-0585-00			2	WIRE, CRT lead, .290 foot, striped brown, with connector
	175-0587-00			1	WIRE, CRT lead, 500 foot, striped red, with connector
	175-0588-00			1	WIRE, CRT lead, .883 foot, striped orange, with connector
	175-0589-00			1	WIRE, CRT lead, 1.380 feet, striped orange, with connector
	175-0592-00			2	WIRE, CRT lead, .960 foot, striped green, with connector
	175-0593-00			2	WIRE, CRT lead, .333 foot, striped blue, with connector
	175-0595-00			1	WIRE, CRT lead, .960 foot, striped red, with connector
89	406-0456-00			1	BRACKET, pot
	- - - - -			-	Mounting Hardware: (not included)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch PHS
	211-0507-00			2	SCREW, 6-32 x 5/16 inch PHS
	210-0803-00			2	WASHER, 6L x 3/8 inch
90	- - - - -			-	Mounting Hardware For Each Pot:
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 7/16 inch OD
91	343-0002-00			1	CLAMP, cable, 3/16 inch
	- - - - -			-	Mounting Hardware: (not included)
	211-0510-00			1	SCREW, 6-32 x 3/8 inch PHS
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0407-00			1	NUT, hex, 6-32 x 1/4 inch
92	406-0576-00			1	BRACKET, miniature pot
	- - - - -			-	Mounting Hardware: (not included)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch PHS
	- - - - -			-	Mounting Hardware For Miniature Pot: (not shown)
	210-0583-00			1	NUT, hex, 1/4-32 x 5/16 inch
	210-0046-00			1	LOCKWASHER, internal, .261 ID x .400 inch OD
93	381-0210-00			1	BAR, top, w/handle
	- - - - -			-	bar includes:
	367-0040-00			2	ASSEMBLY, handle
	- - - - -			-	each assembly includes:
	367-0011-00			1	HANDLE
	343-0073-00			2	CLAMP, handle
	211-0507-00			6	SCREW, 6-32 x 5/16 inch PHS
	210-0457-00			6	NUT, keps, 6-32 x 5/16 inch
	- - - - -			-	Mounting Hardware: (not included w/bar)
	212-0039-00			4	SCREW, 8-32 x 3/8 inch THS
94	381-0073-00			2	BAR, retaining
95	406-0245-00			4	BRACKET, ground clip
96	355-0043-00			4	STUD, graticule, replacement
	- - - - -			-	Each Includes:
	212-0507-00			1	SCREW, 10-32 x 3/8 inch PHS
	210-0010-00			1	LOCKWASHER, internal, #10
97	- - - - -			-	Mounting Hardware For Each Pot:
	210-0413-00			1	NUT, hex, 3/8 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 7/16 inch OD
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 1 1/16 inch
98	214-0433-00	X9000	10409	1	SPRING, light reflector
	354-0262-00	10410		1	RING, light reflector plate
99	387-0917-00	X9000	10409	1	PLATE, light reflector
	386-0212-00	10410		1	PLATE, light reflector
100	124-0166-00	X9000	11539	1	STRIP, CRT shield
	348-0070-01	11540		4	CUSHION, sponge, CRT
101	378-0541-00	X11280		8	FILTER, lens, neon

EXPLODED VIEW-REAR GROUP



EXPLODED VIEW-REAR GROUP

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	387-0719-00			1	PLATE, cabinet side, left
	- - - - -			-	Includes:
	214-0057-00			2	FASTENER, cabinet latch assembly
	- - - - -			-	Each Consisting Of:
	105-0007-00			1	STOP
	210-0480-00			1	NUT, latch, nylon
	210-0847-00			1	WASHER, nylon, .164 ID x .500 inch OD
	213-0033-00			1	SCREW, fastening
2	211-0552-00			2	SCREW, 6-32 x 2 inch BHS
3	166-0038-00			2	TUBE, spacer, $\frac{3}{4}$ inch
4	166-0037-00			2	TUBE, spacer, $\frac{5}{8}$ inch
5	166-0029-00			2	TUBE, spacer, $\frac{1}{8}$ inch
6	406-0175-00			2	BRACKET, plastic, coil mounting
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0407-00			1	NUT, hex, 6-32 x $\frac{1}{4}$ inch
7	166-0103-00			4	TUBE, form, coil retaining
8	337-0303-00			1	SHIELD, calibrator
9	- - - - -			-	Mounting Hardware For Each Pot:
	210-0413-00			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
	210-0840-00			1	WASHER, .390 ID x $\frac{9}{16}$ inch OD
10	136-0008-00			32	SOCKET, STM7G
	- - - - -			-	Mounting Hardware For Each Pot: (not included)
	213-0044-00			2	SCREW, thread cutting, 5-32 x $\frac{3}{16}$ inch PHS phillips
11	348-0003-00			3	GROMMET, $\frac{5}{16}$ inch
12	348-0002-00			32	GROMMET, $\frac{1}{4}$ inch
13	385-0135-00			8	ROD, delrin, $\frac{15}{16}$ inch
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0041-00			1	SCREW, thread cutting, 6-32 x $\frac{3}{8}$ inch THS phillips
14	354-0068-00			2	RING, securing
15	352-0016-00			16	HOLDER, nylon, coil form, without pin
16	352-0017-00			16	HOLDER, nylon, coil form, with pin
17	337-0008-00			1	SHIELD, tube
18	386-0253-00			5	PLATE, metal, small capacitor
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0534-00			2	SCREW, 6-32 x $\frac{5}{16}$ inch PHS with lockwasher
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x $\frac{1}{4}$ inch
19	343-0049-00			2	CLAMP, cable
20	337-0007-00			1	SHIELD, tube
21	200-0257-00			2	COVER, capacitor
22	200-0293-00			2	COVER, capacitor
23	441-0168-00			1	CHASSIS, vertical amplifier
	- - - - -			-	Mounting Hardware: (not included)
	212-0023-00			4	SCREW, 8-32 x $\frac{3}{8}$ inch BHS
	212-0040-00			2	SCREW, 8-32 x $\frac{3}{8}$ inch FHS phillips

EXPLODED VIEW-REAR GROUP (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
24	386-0254-00			2	PLATE, fiber, large capacitor
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0543-00			2	SCREW, 6-32 x $\frac{5}{16}$ inch RHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x $\frac{1}{4}$ inch
25	386-0255-00			2	PLATE, metal, large capacitor
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0534-00			2	SCREW, 6-32 x $\frac{5}{16}$ inch PHS with lockwasher
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x $\frac{1}{4}$ inch
26	348-0004-00			5	GROMMET, $\frac{3}{8}$ inch
27	386-0252-00			2	PLATE, fiber, small capacitor
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0534-00			2	SCREW, 6-32 x $\frac{5}{16}$ inch PHS with lockwasher
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x $\frac{1}{4}$ inch
28	348-0050-00			1	GROMMET, $\frac{3}{4}$ inch
29	348-0012-00			4	GROMMET, $\frac{5}{8}$ inch
30	352-0015-00			8	HOLDER, nylon, coil form
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0045-00			1	SCREW, self-tapping, 4-40 x $\frac{5}{16}$ inch PHS phillips
31	- - - - -			-	Mounting Hardware For Each 8 Watt Resistor:
	212-0037-00			1	SCREW, 8-32 x $1\frac{3}{4}$ inch Fil HS
	210-0601-00			2	EYELET
	210-0205-00			1	LUG, solder, SE8
32	348-0005-00			4	GROMMET, $\frac{1}{2}$ inch
33	210-0202-00			4	LUG, solder, SE6
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0504-00			1	SCREW, 6-32 x $\frac{1}{4}$ inch
	210-0407-00			1	NUT, hex, 6-32 x $\frac{1}{4}$ inch
34	136-0015-00			30	SOCKET, STM9G
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, thread cutting, 5-32 x $\frac{3}{16}$ inch PHS phillips
35	386-0963-00			2	PLATE, termination
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0406-00			1	NUT, hex, 4-40 x $\frac{3}{16}$ inch
	210-0004-00			1	LOCKWASHER, internal, #4
36	386-0964-00			2	PLATE, line
	- - - - -			-	Mounting Hardware For Each: (not included)
	214-0013-00			2	BOLT, spade
	211-0504-00			2	SCREW, 6-32 x $\frac{1}{4}$ inch BHS
	210-0407-00			6	NUT, hex, 6-32 x $\frac{1}{4}$ inch
	210-0006-00			2	LOCKWASHER, internal, #6
37	441-0248-00			1	CHASSIS, delay line, vertical, right side
	- - - - -			-	Mounting Hardware: (not included)
	211-0537-00			2	SCREW, 6-32 x $\frac{3}{8}$ inch THS phillips
	211-0565-00			2	SCREW, 6-32 x $\frac{1}{4}$ inch THS phillips

EXPLODED VIEW-REAR GROUP (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
38	441-0250-00			1	CHASSIS, delay line, vertical, right side
39	441-0247-00			1	CHASSIS, delay line, horizontal, right side
	- - - - -			-	Mounting Hardware: (not included)
	211-0511-00			1	SCREW, 6-32 x 1/2 inch BHS
	210-0803-00			1	WASHER, 6L x 3/8 inch
	166-0093-00			1	TUBE, spacing, 3/16 inch
40	387-0713-00			2	PLATE, mounting, delay line, horizontal
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0510-00			3	SCREW, 6-32 x 3/8 inch BHS
41	- - - - -			-	Mounting Hardware For Each 10 Watt Resistor:
	211-0553-00			1	SCREW, 6-32 x 1 1/2 inch RHS phillips
	210-0601-00			1	EYELET
	210-0478-00			1	NUT, hex, resistor mounting
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
42	- - - - -			-	Mounting Hardware For 5 Watt Resistor:
	211-0544-00			1	SCREW, 6-32 x 3/8 inch THS phillips
	210-0478-00			1	NUT, hex, resistor mounting
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
43	441-0249-00			1	CHASSIS, delay line horizontal, right side
44	387-0712-00			2	PLATE, mounting, delay line
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0510-00			3	SCREW, 6-32 x 3/8 inch BHS
	210-0202-00			2	LUG, solder, SE6
	210-0204-00			1	LUG, solder, DE6
45	441-0236-00			1	CHASSIS, horizontal amplifier and high voltage, right side
	- - - - -			-	Mounting Hardware: (not included)
	212-0040-00			5	SCREW, 8-32 x 3/8 inch FHS phillips
	210-0458-00			2	NUT, keps, 8-32 x 1 1/32 inch
46	385-0138-00			3	ROD, delrin, with four holes
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0041-00			1	SCREW, thread cutting, 6-32 x 3/8 inch THS phillips
47	337-0009-00			2	SHIELD, tube
48	441-0115-00			1	CHASSIS, delay line, vertical, left side
49	441-0235-00			1	CHASSIS, horizontal amplifier and high voltage, left side
	- - - - -			-	Mounting Hardware: (not included)
	212-0040-00			5	SCREW, 8-32 x 3/8 inch FHS phillips
	210-0458-00			2	NUT, keps, 8-32 x 1 1/32 inch
50	337-0005-00			3	SHIELD, socket, 9 pin
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0033-00			2	SCREW, 4-40 x 5/16 inch PHS with lockwasher
	210-0004-00			4	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
51	337-0004-00			1	SHIELD, socket, 7 pin
	- - - - -			-	Mounting Hardware: (not included)
	211-0033-00			2	SCREW, 4-40 x 5/16 inch PHS with lockwasher
	210-0004-00			4	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch

EXPLODED VIEW-REAR GROUP (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
52	385-0090-00			2	ROD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0041-00			1	SCREW, thread cutting, 6-32 x 3/8 inch THS phillips
	210-0005-00			1	LOCKWASHER, external, #6
53	441-0264-00			1	CHASSIS, delay line, vertical, left side
	- - - - -			-	Mounting Hardware: (not included)
	211-0537-00			2	SCREW, 6-32 x 3/8 inch THS phillips
	211-0565-00			2	SCREW, 6-32 x 1/4 inch THS phillips
54	441-0114-00			1	CHASSIS, delay line, horizontal, left side
55	441-0263-00			1	CHASSIS, delay line, horizontal, left side
	- - - - -			-	Mounting Hardware: (not included)
	211-0511-00			1	SCREW, 6-32 x 1/2 inch BHS
	210-0803-00			1	WASHER, 6L x 3/8 inch
	166-0093-00			1	TUBE, spacing, 3/16 inch
56	214-0210-00			1	SPOOL, solder, assembly
	- - - - -			-	Includes:
	214-0209-00			1	SPOOL, solder
	- - - - -			-	Mounting Hardware: (not included)
	361-0007-00			1	SPACER, nylon, .063 inch
57	337-0286-00			1	SHIELD, high voltage, left
	- - - - -			-	Mounting Hardware: (not included)
	211-0541-00			2	SCREW, 6-32 x 1/4 inch FHS phillips
	213-0054-00			1	SCREW, thread cutting, 6-32 x 5/16 inch PHS phillips
58	406-0465-00			1	BRACKET, pot
	- - - - -			-	Mounting Hardware: (not included)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch BHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
59	346-0001-00			1	STRAP, transformer
	- - - - -			-	Mounting Hardware: (not included)
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
	210-0004-00			2	LOCKWASHER, internal, #4
60	337-0284-00			2	SHIELD, horizontal display
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch BHS
61	441-0245-00			1	CHASSIS, external amplifier
	- - - - -			-	Mounting Hardware: (not included)
	211-0507-00			6	SCREW, 6-32 x 5/16 inch BHS
	210-0457-00			6	NUT, keps, 6-32 x 5/16 inch
62	386-0897-00			1	PLATE, high voltage board
	- - - - -			-	Mounting Hardware: (not included)
	211-0507-00			6	SCREW, 6-32 x 5/16 inch BHS
63	385-0080-00			3	ROD, hex
	210-0006-00			3	LOCKWASHER, internal, #6
64	346-0010-00			1	STRAP, transformer
	- - - - -			-	Mounting Hardware: (not included)
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
	210-0004-00			2	LOCKWASHER, internal, #4

EXPLODED VIEW-REAR GROUP (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
65	337-0285-00			1	SHIELD, high voltage, right
	- - - - -			-	Mounting Hardware: (not included)
	211-0541-00			2	SCREW, 6-32 x 1/4 inch FHS phillips
	213-0054-00			1	SCREW, thread cutting, 6-32 x 5/16 inch PHS phillips
66	406-0466-00			1	BRACKET, pot
	- - - - -			-	Mounting Hardware: (not included)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
67	337-0281-00			1	SHIELD
68	386-0898-00			1	PLATE, rear subpanel
	- - - - -			-	Includes:
	354-0076-00			1	RING, ornamental
69	441-0246-00			1	CHASSIS, delay pick-off
	- - - - -			-	Mounting Hardware : (not included)
	211-0507-00			4	SCREW, 6-32 x 5/16 inch PHS
	210-0202-00			1	LUG, solder, SE6
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
70	635-0409-00	7000	11479	1	ASSEMBLY, fan motor
	635-0432-00	11480		1	ASSEMBLY, fan motor
	- - - - -			-	assembly includes:
	147-0001-00			1	MOTOR, 1500 RPM, 115 V
	- - - - -			-	Mounting Hardware: (not included)
	355-0044-00			2	STUD, 10-32 x 27/16 inches
	210-0410-00			4	NUT, hex, 10-32 x 5/16 inch
	210-0010-00			6	LOCKWASHER, internal, #10
71	354-0053-00			1	RING, fan
72	369-0007-00			1	FAN, 7 inch blade
73	348-0008-00			3	SHOCKMOUNT
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0409-00			2	NUT, hex, 8-32 x 5/16 inch
	210-0008-00	7000	11479	2	LOCKWASHER, internal, #8
	210-0008-00	11480		1	LOCKWASHER, internal, #8
	210-0205-00	11480		1	LUG, solder, SE #8
74	426-0047-00			1	MOUNT, fan motor
	- - - - -			-	Mounting Hardware: (not included w/assembly)
	213-0104-00			6	SCREW, thread forming, 6-32 x 3/8 inch THS phillips
75	334-0649-00			1	TAG, voltage rating
	- - - - -			-	Mounting Hardware: (not included)
	213-0088-00			2	SCREW, thread forming, 4-40 x 1/4 inch PHS phillips
76	387-0718-00			1	PLATE, cabinet bottom
	- - - - -			-	Includes:
	214-0057-00			4	FASTENER, cabinet latch assembly
	- - - - -			-	Each Consisting Of:
	105-0007-00			1	STOP
	210-0480-00			1	NUT, latch, nylon
	210-0847-00			1	WASHER, nylon, .164 ID x .500 inch OD
	213-0033-00			1	SCREW, fastening

EXPLODED VIEW-REAR GROUP (Cont'd)

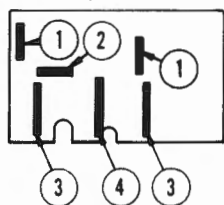
REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
77	378-0023-00			1	FILTER, air, foam
78	378-0762-00			1	SCREEN, filter
79	131-0077-00			1	CONNECTOR, chassis mount, 16 contact
	- - - - -			-	Mounting Hardware: (not included)
	211-0013-00			2	SCREW, 4-40 x $\frac{3}{16}$ inch RHS
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0201-00			1	LUG, solder, SE4
	210-0406-00			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch
80	380-0018-00			1	HOUSING, air filter
	- - - - -			-	Mounting Hardware: (not included)
	212-0031-00			2	SCREW, 8-32 x $1\frac{1}{4}$ inch RHS
	210-0458-00			2	NUT, keps, 8-32 x $1\frac{1}{32}$ inch
	210-0402-00			2	NUT, cap, hex, 8-32 x $\frac{5}{16}$ inch
81	366-0033-00	7000	10869	1	KNOB, ext. HORIZ. GAIN, LOWER BEAM, small black
	366-0148-00	10870		1	KNOB, ext. HORIZ. GAIN, LOWER BEAM, small charcoal
	- - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
82	387-0085-00			1	PLATE, rear overlay
	- - - - -			-	Mounting Hardware: (not included)
	213-0104-00			4	SCREW, thread forming 6-32 x $\frac{3}{8}$ inch THS phillips
83	129-0036-00	7000	10869	2	POST, binding, black
	129-0063-00	10870		2	POST, binding, charcoal
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0445-00	7000	7279	1	NUT, hex, 10-32 x $\frac{3}{8}$ inch
	220-0410-00	7280		1	NUT, keps, 10-32 x $\frac{3}{8}$ inch
	210-0010-00	7000	7279X	1	LOCKWASHER, internal, #10
84	387-0084-00			1	PLATE, cabinet side, right
	- - - - -			-	Includes:
	214-0057-00			2	FASTENER, cabinet latch assembly
	- - - - -			-	Each Consisting Of:
	105-0007-00			1	STOP
	210-0480-00			1	NUT, latch, nylon
	210-0847-00			1	WASHER, nylon, .164 ID x .500 inch OD
	213-0033-00			1	SCREW, fastening
85	260-0209-00			2	SWITCH, CRT CATHODE SELECTOR, toggle
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0473-00			1	NUT, switch, 12 sided
	210-0902-00			1	WASHER, .470 ID x $2\frac{1}{32}$ inch OD
	354-0055-00			1	RING, locking, switch
	210-0414-00			1	NUT, hex, $1\frac{1}{32}$ -32 x $\frac{3}{16}$ inch
86	129-0051-00			2	POST, binding, assembly
	- - - - -			-	Each Consisting Of:
	355-0507-00			1	STEM, adapter
	200-0182-00			1	CAP
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0455-00			1	NUT, hex, $\frac{1}{4}$ -28 x $\frac{3}{8}$ inch
	210-0046-00			1	LOCKWASHER, internal, .400 OD x .261 inch ID

EXPLODED VIEW-REAR GROUP (Cont'd)

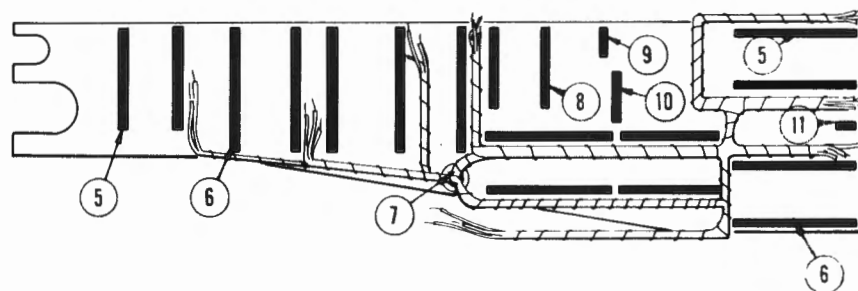
REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
87	366-0033-00	7000	10869	1	KNOB, EXT. HORIZ. GAIN, UPPER BEAM, small black
	366-0148-00	10870		1	KNOB, EXT. HORIZ. GAIN, UPPER BEAM, small charcoal
	- - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
88	129-0036-00	7000	10869	4	POST, binding, black
	129-0063-00	10870		4	POST, binding, charcoal
89	- - - - -			-	Mounting Hardware For Each: (not included)
	358-0036-00	7000	10869	1	BUSHING, binding post, black
	358-0169-00	10870		1	BUSHING, binding post, charcoal
	210-0206-00	7000	7279X	1	LUG, solder, SE10
	210-0010-00	7000	7279X	1	LOCKWASHER, internal, #10
	210-0445-00	7000	7279	2	NUT, hex, 10-32 x $\frac{3}{8}$ inch
	220-0410-00	7280		1	NUT, keps, 10-32 x $\frac{3}{8}$ inch
	- - - - -			-	
90	386-0427-00			2	PLATE, ground
91	- - - - -			-	Mounting Hardware For Each Coil:
	211-0036-00			1	SCREW, 4-40 x $\frac{1}{2}$ inch BH nylon
92	- - - - -			-	Mounting Hardware For Thermal Cutout:
	211-0504-00			2	SCREW, 6-32 x $\frac{1}{4}$ inch BHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x $\frac{1}{4}$ inch
93	- - - - -			-	Mounting Hardware For Each Pot:
	210-0413-00			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
	210-0840-00			1	WASHER, .390 ID x $\frac{9}{16}$ inch OD
	210-0013-00			1	LOCKWASHER, internal, $\frac{3}{8}$ x $\frac{11}{16}$ inch
94	- - - - -			-	Mounting Hardware For Each 5 Watt Resistor:
	212-0031-00			1	SCREW, 8-32 x $1\frac{1}{4}$ inch RHS
	210-0804-00			2	WASHER, 8S x $\frac{3}{8}$ inch
95	348-0005-00	7000	10879	2	GROMMET, rubber, $\frac{1}{2}$ inch
	348-0063-00	10880		2	GROMMET, plastic, $\frac{1}{2}$ inch

CABLE HARNESS AND CERAMIC STRIP DETAIL

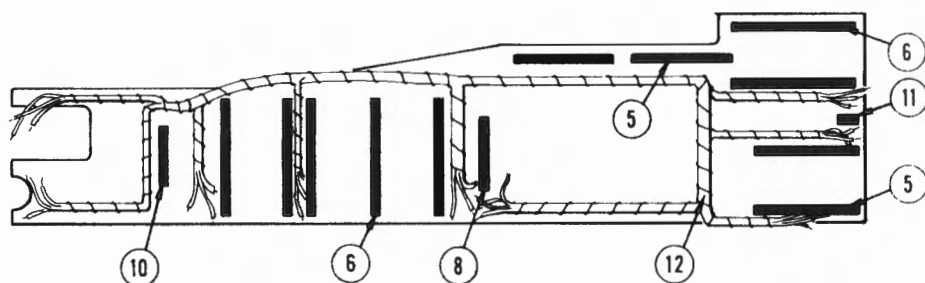
HIGH VOLTAGE



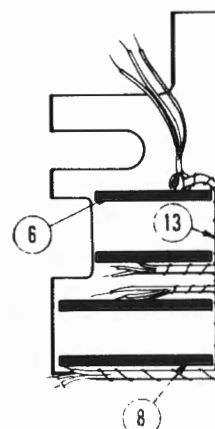
LEFT HORIZONTAL AMPLIFIER CHASSIS



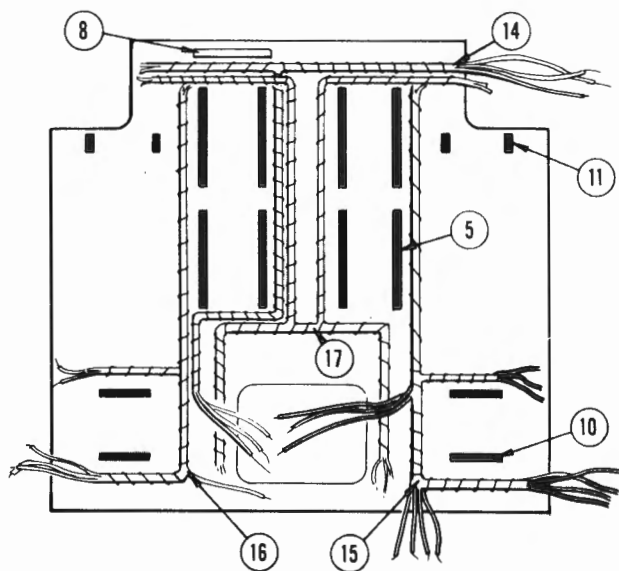
RIGHT HORIZONTAL AMPLIFIER CHASSIS



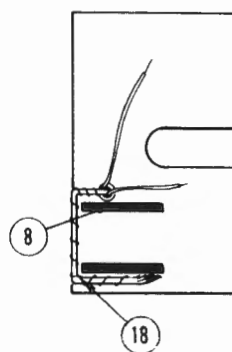
DELAY CHASSIS



VERTICAL AMPLIFIER CHASSIS



EXTERNAL AMPLIFIER CHASSIS



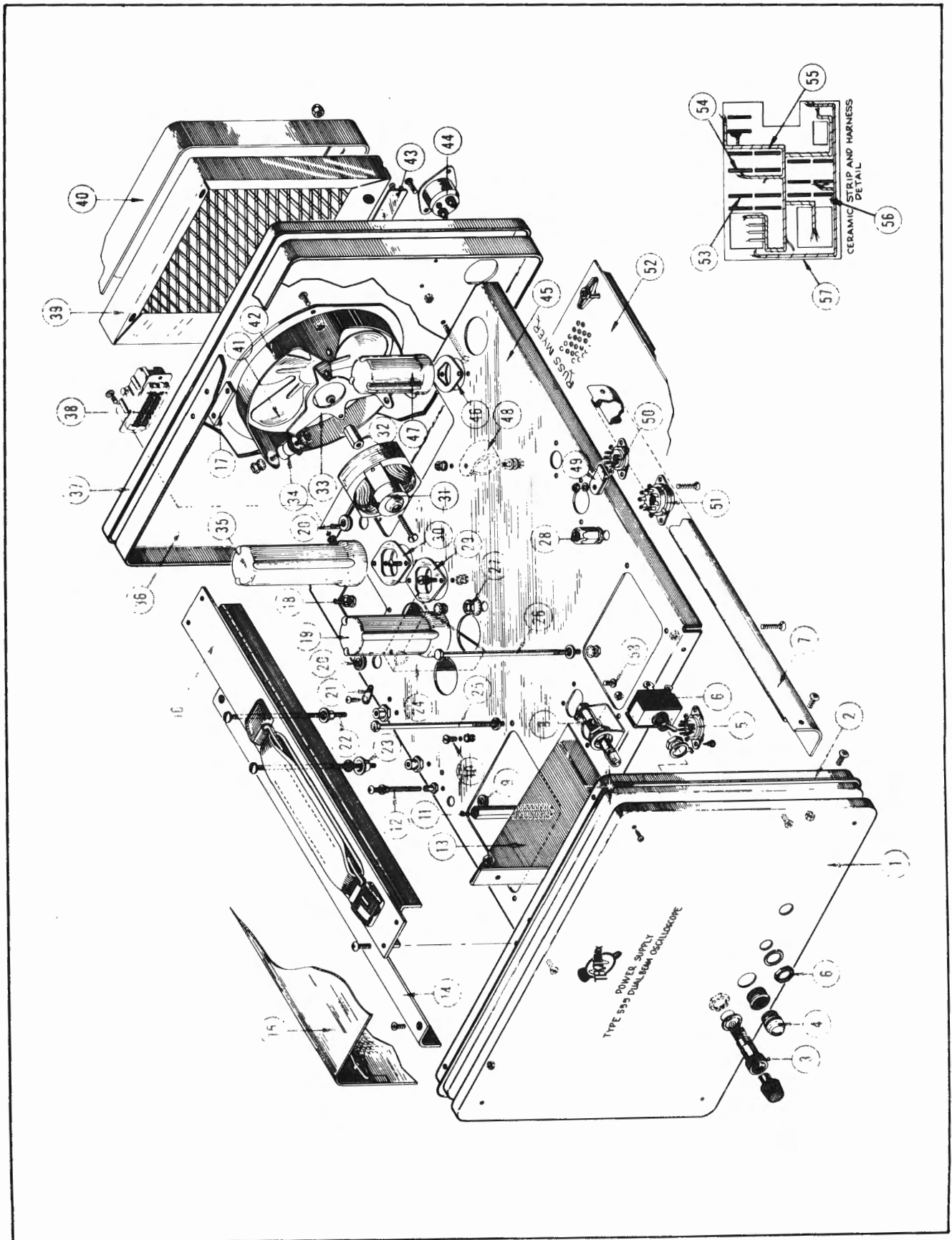
CABLE HARNESS AND CERAMIC STRIP DETAIL

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	124-0087-00			2	STRIP, ceramic, $\frac{3}{4}$ inch x 3 notches
	- - - - -			-	Each Includes:
	355-0046-00			1	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			1	SPACER, nylon, .313 inch
2	124-0092-00			1	STRIP, ceramic, $\frac{7}{16}$ inch x 3 notches
	- - - - -			-	Includes:
	355-0046-00			1	STUD, nylon
	- - - - -			-	Mounting Hardware: (not included)
	361-0008-00			1	SPACER, nylon, .188 inch
3	124-0088-00			2	STRIP, ceramic, $\frac{3}{4}$ inch x 4 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, .313 inch
4	124-0093-00			1	STRIP, ceramic, $\frac{7}{16}$ inch x 5 notches
	- - - - -			-	Includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	Mounting Hardware: (not included)
	361-0008-00			2	SPACER, nylon, .188 inch
5	124-0090-00			18	STRIP, ceramic, $\frac{3}{4}$ inch x 9 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0008-00			2	SPACER, nylon, .188 inch
6	124-0091-00			18	STRIP, ceramic, $\frac{3}{4}$ inch x 11 notches
	- - - - -			-	Each includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0008-00			2	SPACER, nylon, .188 inch
7	179-0559-00			1	CABLE HARNESS, left horizontal amplifier
8	124-0089-00			10	STRIP, ceramic, $\frac{3}{4}$ inch x 7 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0008-00			2	SPACER, nylon, .188 inch
9	124-0086-00			1	STRIP, ceramic, $\frac{3}{4}$ inch x 2 notches
	- - - - -			-	Includes:
	355-0046-00			1	STUD, nylon
	- - - - -			-	Mounting Hardware: (not included)
	361-0008-00			1	SPACER, nylon, .188 inch

CABLE HARNESS AND CERAMIC STRIP DETAIL (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
10	124-0088-00			6	STRIP, ceramic, $\frac{3}{4}$ inch x 4 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0008-00			2	SPACER, nylon, .188 inch
11	124-0100-00			6	STRIP, ceramic, $\frac{3}{4}$ inch x 1 notch
	- - - - -			-	Each Includes:
	355-0046-00			1	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0008-00			1	SPACER, nylon, .188 inch
12	179-0558-00			1	CABLE HARNESS, right horizontal amplifier
13	179-0310-00			1	CABLE HARNESS, delay pick-off (large)
	179-0365-00			1	CABLE HARNESS, delay pick-off (small)
14	179-0313-00			1	CABLE HARNESS, 110 volt
15	179-0378-00			1	CABLE HARNESS, vertical amplifier (channel A)
16	179-0379-00			1	CABLE HARNESS, vertical amplifier (channel B)
17	179-0840-00			1	CABLE HARNESS, bulkhead
18	179-0311-00			1	CABLE HARNESS, external amplifier

EXPLODED VIEW-POWER SUPPLY



EXPLODED VIEW-POWER SUPPLY

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	333-0393-00			1	PANEL, front
	- - - - -			-	Mounting Hardware: (not included)
	213-0088-00			4	SCREW, thread forming, 4-40 x 1/4 inch PHS phillips
2	386-0712-00			1	PLATE, front subpanel
	- - - - -			-	Includes:
	354-0057-00			1	RING, ornamental
3	352-0002-00			2	HOLDER, fuse assembly
	- - - - -			-	Each Consisting Of:
	352-0010-00			1	HOLDER, fuse
	200-0015-00			1	CAP, fuse
	210-0873-00			1	WASHER, rubber
	- - - - -			1	NUT, fuse holder
4	378-0518-00			1	JEWEL, pilot light
5	136-0015-00			6	SOCKET, STM9G
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
6	260-0276-00			1	SWITCH, POWER, toggle
	- - - - -			-	Mounting Hardware: (not included)
	210-0473-00			1	NUT, switch, 12 sided
	210-0902-00			1	WASHER, .470 ID x 21/32 inch OD
	354-0055-00			1	RING, locking, switch
	210-0414-00			1	NUT, hex, 15/32-32 x 9/16 inch
7	122-0067-00			2	ANGLE, frame, bottom
	- - - - -			-	Mounting Hardware For Each: (not included)
	212-0039-00			4	SCREW, 8-32 x 3/8 inch THS phillips
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
8	136-0025-00			1	SOCKET, light, with nut
9	348-0003-00			1	GROMMET, 5/16 inch
10	- - - - -			-	Mounting Hardware For Thermal Cutout:
	211-0504-00			2	SCREW, 6-32 x 1/4 inch BHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
11	385-0140-00			2	ROD, support
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0522-00			1	SCREW, 6-32 x 5/8 inch FHS phillips
12	- - - - -			-	Mounting Hardware For 10 Watt Resistor:
	211-0553-00			1	SCREW, 6-32 x 1 1/2 inch RHS phillips
	210-0601-00			1	EYELET
	210-0478-00			1	NUT, hex, resistor mounting
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
13	406-0294-00			1	BRACKET, transformer support
	- - - - -			-	Mounting Hardware: (not included)
	211-0510-00			3	SCREW, 6-32 x 3/8 inch BHS
	210-0457-00			3	NUT, keps, 6-32 x 5/16 inch
	212-0040-00			3	SCREW, 8-32 x 3/8 inch FHS phillips
	210-0458-00			3	NUT, keps, 8-32 x 11/32 inch

EXPLODED VIEW-POWER SUPPLY (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
14	122-0043-00			2	ANGLE, frame, top
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0559-00			4	SCREW, 6-32 x $\frac{3}{8}$ inch FHS phillips
	210-0457-00			4	NUT, keps, 6-32 x $\frac{5}{16}$ inch
15	387-0063-00			2	PLATE, cabinet side
	- - - - -			-	Each Includes:
	214-0057-00			2	FASTENER, cabinet latch assembly
	- - - - -			-	Each Consisting Of:
	105-0007-00			1	STOP
	210-0480-00			1	NUT, latch, nylon
	210-0847-00			1	WASHER, nylon, .164 ID x .500 inch OD
	213-0033-00			1	SCREW, fastening
	381-0207-00			1	BAR, top support, w/handle
	- - - - -			-	bar includes:
	367-0040-00			1	ASSEMBLY, handle
	- - - - -			-	assembly includes:
	367-0011-00			1	HANDLE
	343-0073-00			2	CLAMP, handle
	211-0507-00			6	SCREW, 6-32 x $\frac{5}{16}$ inch BHS
	210-0457-00			6	NUT, keps, 6-32 x $\frac{5}{16}$ inch
	- - - - -			-	Mounting Hardware: (not included)
	212-0039-00			4	SCREW, 8-32 x $\frac{3}{8}$ inch THS phillips
17	381-0073-00			2	BAR, retaining
18	- - - - -			-	Mounting Hardware For Fixed Coil:
	210-0564-00			4	NUT hex, 10-32 x $\frac{3}{8}$ inch
	210-0010-00			4	LOCKWASHER, internal, #10
19	200-0258-00			2	COVER, capacitor
20	348-0004-00			2	GROMMET, $\frac{3}{8}$ inch
21	210-0201-00			2	LUG, solder, SE4
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			1	SCREW, thread cutting, 5-32 x $\frac{3}{16}$ inch PHS phillips
22	- - - - -			-	Mounting Hardware For 20 Watt Resistor:
	212-0037-00			1	SCREW, 8-32 x $1\frac{3}{4}$ inch fil HS
	210-0808-00			3	WASHER, resistor centering
	210-0462-00			1	NUT, hex, resistor mounting
	212-0004-00			1	SCREW, 8-32 x $\frac{5}{16}$ inch BHS
23	- - - - -			-	Mounting Hardware For Each 25 Watt Resistor:
	212-0037-00			1	SCREW, 8-32 x $1\frac{3}{4}$ inch fil HS
	210-0008-00			1	LOCKWASHER, internal, #8
	210-0809-00			3	WASHER, resistor centering
	210-0462-00			1	NUT, hex, resistor mounting
	212-0004-00			1	SCREW, 8-32 x $\frac{5}{16}$ inch BHS
24	406-0590-00			1	BRACKET, transformer support
	- - - - -			-	Mounting Hardware: (not included)
	211-0522-00			1	SCREW, 6-32 x $\frac{5}{8}$ inch FHS phillips
	210-0457-00			1	NUT, keps, 6-32 x $\frac{5}{16}$ inch

EXPLODED VIEW-POWER SUPPLY (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
25	- - - - - 212-0547-00 210-0812-00 210-0010-00 210-0564-00			- 4 4 4 3	Mounting Hardware For Transformer: SCREW, 10-32 x 4 ³ / ₄ inch HHS WASHER, fiber, #10 LOCKWASHER, internal, #10 NUT, hex, 10-32 x ³ / ₈ inch
26	- - - - - 212-0017-00 212-0542-00 210-0812-00 210-0458-00 220-0410-00	7000 7760 X7760 7000 7760	7759 7759	- 4 4 4 4 4	Mounting Hardware For Transformer: SCREW, 8-32 x 5 inches HHS SCREW, 10-32 x 5 inch HHS WASHER, fiber #10 NUT, keps, 8-32 x 1 ¹ / ₃₂ inch NUT, keps, 10-32 x ³ / ₈ inch
27	- - - - - 210-0413-00 210-0840-00			- 1 1	Mounting Hardware For Pot: NUT, hex, ³ / ₈ -32 x 1 ¹ / ₂ inch WASHER, .390 ID x ⁹ / ₁₆ inch OD
28	- - - - - 210-0444-00 210-0840-00			- 1 1	Mounting Hardware For Pot: NUT, hex, ³ / ₈ -32 x 1 ¹ / ₂ inch x ⁵ / ₈ inch WASHER, .390 ID x ⁹ / ₁₆ inch OD
29	386-0255-00 - - - - - 211-0534-00 210-0006-00 210-0407-00			2 - 2 2 2	PLATE, metal, large capacitor Mounting Hardware For Each: (not included) SCREW, 6-32 x ⁵ / ₁₆ inch PHS with lockwasher LOCKWASHER, internal, #6 NUT, hex, 6-32 x 1 ¹ / ₄ inch
30	386-0254-00 - - - - - 211-0543-00 210-0006-00 210-0407-00			4 - 2 2 2	PLATE, fiber, large capacitor Mounting Hardware For Each: (not included) SCREW, 6-32 x ⁵ / ₁₆ inch RHS LOCKWASHER, internal, #6 NUT, hex, 6-32 x 1 ¹ / ₄ inch
31	147-0021-00 - - - - - 212-0004-00 212-0020-00			1 - 2 2	MOTOR, 2770 RPM, 110 volt Mounting Hardware: (not included) SCREW, 8-32 x ⁵ / ₁₆ inch BHS SCREW, 8-32 x 1 inch BHS
32	166-0098-00			2	TUBE, spacing
33	426-0075-00			1	MOUNT, fan motor
34	348-0008-00 - - - - - 210-0409-00 210-0008-00			3 - 2 2	SHOCKMOUNT Mounting Hardware For Each: (not included) NUT, hex, 8-32 x ⁵ / ₁₆ inch LOCKWASHER, internal, #8
35	200-0261-00			2	COVER, capacitor
36	386-0749-00 - - - - - 354-0057-00			1 - 1	PLATE, rear subpanel Includes: RING, ornamental
37	387-0086-00 - - - - - 213-0104-00			1 - 2	PLATE, rear overlay Mounting Hardware: (not included) SCREW, thread forming, 6-32 x ³ / ₈ inch THS phillips
38	131-0078-00 - - - - - 211-0013-00 210-0004-00 210-0406-00			1 - 2 2 2	CONNECTOR, chassis mount, 16 contact Mounting Hardware (not included) SCREW, 4-40 x ³ / ₈ inch RHS LOCKWASHER, internal, #4 NUT, hex, 4-40 x ³ / ₁₆ inch

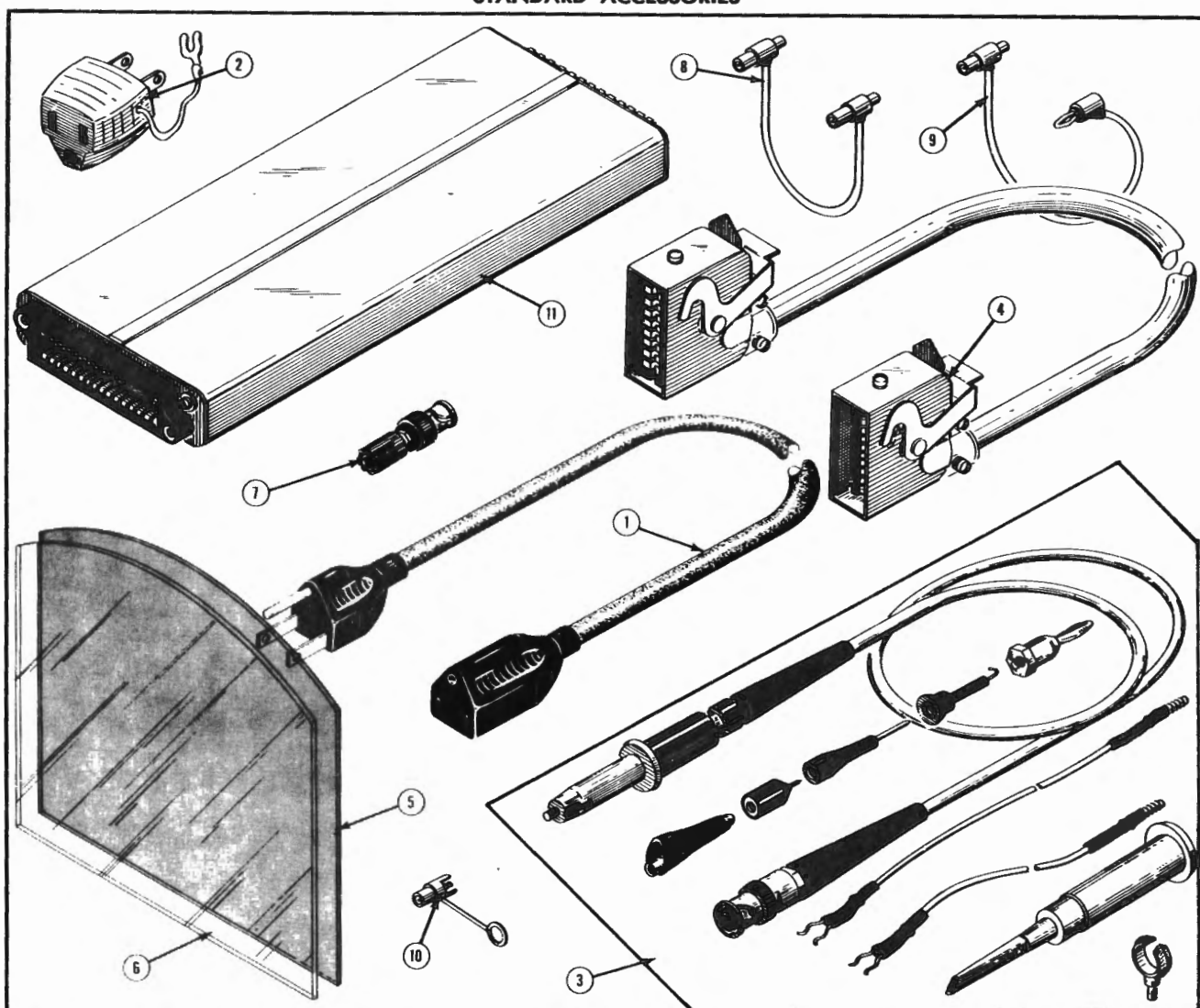
EXPLODED VIEW-POWER SUPPLY (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
39	378-0015-00	7000	9989	1	FILTER, air
	378-0031-00	9990		1	FILTER, air
	378-0763-00	X9990		1	SCREEN, filter
40	380-0016-00			1	HOUSING, air filter
	212-0031-00			-	Mounting Hardware: (not included)
	210-0458-00			4	SCREW, 8-32 x 1 1/4 inch RHS
	210-0402-00			4	NUT, keps, 8-32 x 1 1/32 inch
41	369-0001-00			4	NUT, cap, hex, 8-32 x 5/16 inch
42	354-0051-00			1	FAN, 5 1/2 inch blade
				1	RING, fan
	211-0537-00			-	Mounting Hardware: (not included)
	334-0649-00			6	SCREW, 6-32 x 3/8 inch THS
43				1	TAG, voltage rating
	213-0088-00			-	Mounting Hardware: (not included)
	131-0150-00	7000	11899	2	SCREW, thread forming, 4-40 x 1/4 inch PHS
	131-0150-01	11900		1	CONNECTOR, chassis mount, motor base
				1	CONNECTOR, chassis mount, motor base
				-	connector includes:
	129-0041-00	7000	11899	1	POST, ground
	129-0041-01	11900		1	POST, ground
	200-0185-00	7000	11899	1	COVER
	200-0185-01	11900		1	COVER
	205-0014-00			1	SHELL, mounting
	210-0003-00	7000	11899X	2	LOCKWASHER, external, #4
	210-0551-00	7000	11899X	2	NUT, hex., 4-40 x 1/4 inch
	211-0132-00	X11900		2	SCREW, sems, 4-40 x 1/2 inch, PHS
	211-0015-00	7000	11899	1	SCREW, 4-40 x 1/2 inch, RHS
	213-0088-00	11900		1	SCREW, thread forming, #4 x 1/4 inch, PHS
	214-0078-00			2	PIN, connecting
	377-0041-00	7000	11899	1	INSERT, plastic
	377-0051-00	11900		1	INSERT, plastic
				-	Mounting Hardware: (not included)
	213-0104-00			2	SCREW, thread forming, 6-32 x 3/8 inch THS
45	441-0252-00			1	CHASSIS, power supply
				-	Mounting Hardware: (not included)
	212-0040-00			8	SCREW, 8-32 x 3/8 inch FHS
	210-0206-00			1	LUG, solder, SET0
	210-0458-00			8	NUT, keps, 8-32 x 1 1/32 inch
46	386-0252-00			1	PLATE, fiber, small capacitor
				-	Mounting Hardware: (not included)
	211-0534-00			2	SCREW, 6-32 x 5/16 inch PHS with lockwasher
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
47	200-0256-00			1	COVER, capacitor
48	343-0014-00			1	CLAMP, cable, 1 inch
				-	Mounting Hardware: (not included)
	211-0511-00			1	SCREW, 6-32 x 1/2 inch BHS
	210-0803-00			2	WASHER, 6L x 3/8 inch
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
	210-0006-00			1	LOCKWASHER, internal, #6
49	343-0001-00			1	CLAMP, cable, 1/8 inch
				-	Mounting Hardware: (not included)
	211-0522-00			1	SCREW, 6-32 x 5/8 inch FHS
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch

EXPLODED VIEW-POWER SUPPLY (Cont'd)

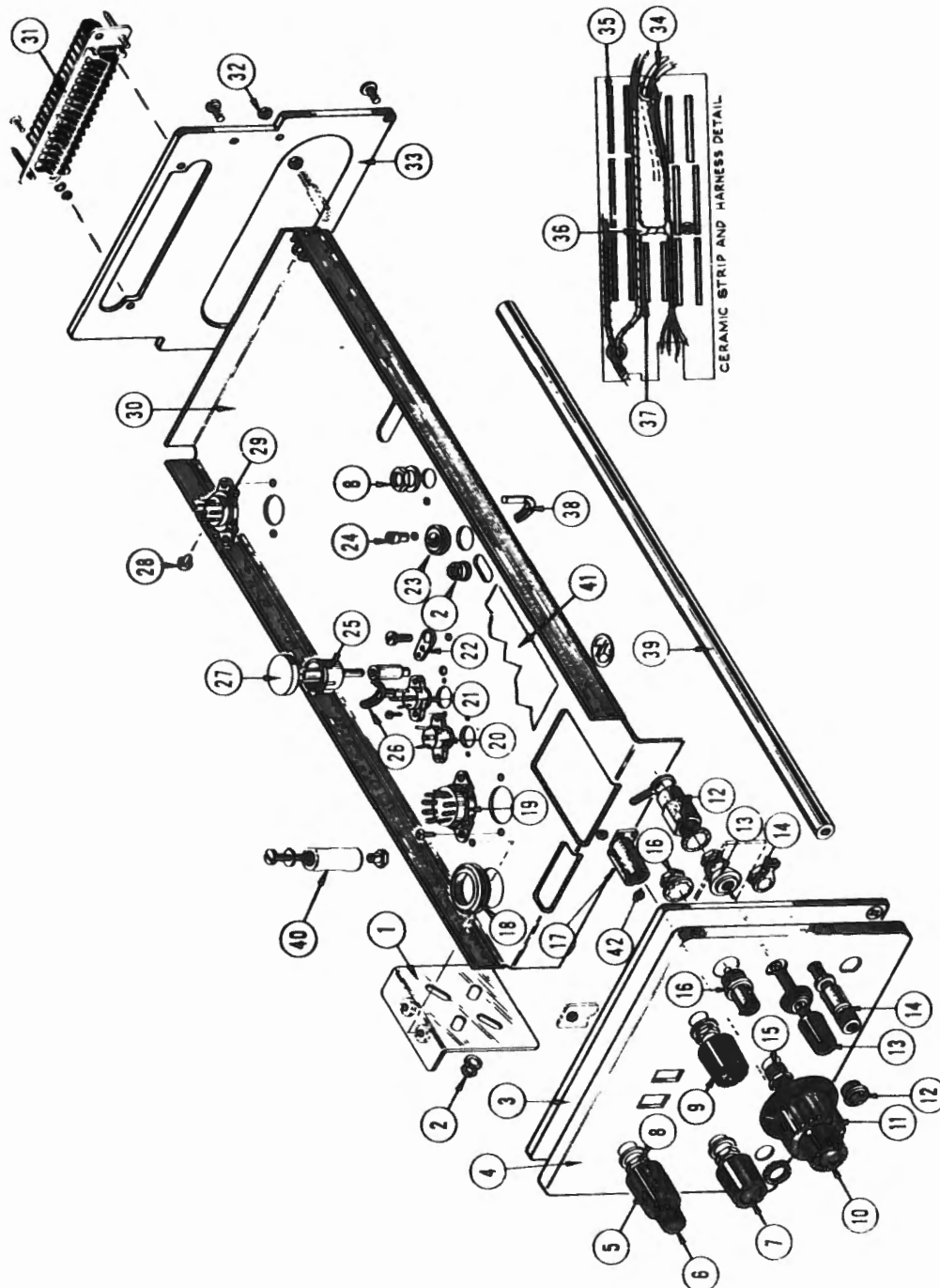
REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
50	136-0008-00			6	SOCKET, STM7G
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, thread cutting, 5-32 x $\frac{3}{16}$ inch PHS phillips
51	136-0011-00			6	SOCKET, STM8
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0538-00			2	SCREW, 6-32 x $\frac{3}{16}$ inch FHS phillips
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x $\frac{1}{4}$ inch
52	387-0064-00			1	PLATE, cabinet bottom
	- - - - -			-	Includes:
	214-0057-00			4	FASTENER, cabinet latch assembly
	- - - - -			-	Each Consisting Of:
	105-0007-00			1	STOP
	210-0480-00			1	NUT, latch, nylon
	210-0847-00			1	WASHER, nylon, .164 ID x .500 inch OD
	213-0033-00			1	SCREW, fastening
53	124-0089-00			3	STRIP, cermaic, $\frac{3}{4}$ inch x 7 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, .313 inch
54	124-0091-00			11	STRIP, ceramic, $\frac{3}{4}$ inch x 11 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, .313 inch
55	179-0546-00			1	CABLE, HARNESS, power
56	124-0090-00			3	STRIP, ceramic, $\frac{3}{4}$ inch x 9 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, .313 inch
57	179-0327-00			1	CABLE HARNESS, 110 volt
58	- - - - -			-	Mounting Hardware For Holding Relay:
	211-0503-00			2	SCREW, 6-32 x $\frac{3}{16}$ inch BHS

STANDARD ACCESSORIES



REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	161-0010-00	7000	11839	1	CORD, power
	161-0010-03	11840		1	CORD, power
2	103-0013-00			1	ADAPTER, 3- to 2-wire
3	010-0127-00			4	PROBE, package, P6006
4	012-0032-00			1	CORD, connecting
5	378-0514-00	7000	8999	1	FILTER, light
	378-0545-00	9000	10506	1	FILTER, light, smoke gray (installed)
	378-0567-00	10507		1	FILTER, light, smoke gray (installed)
6	387-0918-00	X9000		1	PLATE, implosion shield
7	103-0033-00	7000	10000X	2	ADAPTER, BNC to binding post
8	012-0031-00	7000	10000	1	CORD, patch
	012-0087-00	10001		2	CORD, patch
9	012-0091-00	X10001		1	CORD, patch
10	012-0092-00	X10001		1	JACK BNC-post
11	013-0013-00			1	EXTENSION, time base
--	070-0403-00	7000		2	MANUAL, instruction (not shown)

EXPLODED VIEW



EXPLODED VIEW

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	406-0944-00	7000	10999	1	BRACKET, pot mounting
	406-0944-01	11000		1	BRACKET, pot mounting
	-----			-	Mounting Hardware: (not included)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch BHS
2	-----			-	Mounting Hardware For Small Pots
	211-0583-00			5	NUT, hex, 1/4-32 x 3/16 inch
	210-0046-00			5	LOCKWASHER, internal, .400 OD x .261 inch ID
3	387-0823-00			1	PLATE, front sub-panel
4	333-0773-00			1	PANEL, front
5	366-0257-00	7000	10999	1	KNOB, LEVEL, small black
	366-0332-00	11000		1	KNOB, LEVEL, small charcoal
	-----			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
6	366-0255-00			1	KNOB, VERNIER, small red
	-----			-	Includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch HSS
7	366-0044-00	7000	10999	1	KNOB, SWEEP FUNCTION, small black
	366-0113-00	11000		1	KNOB, SWEEP FUNCTION, small charcoal
	-----			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
8	-----			-	Mounting Hardware For Pots:
	210-0413-00			2	NUT, hex, 3/8-32 x 1/2 inch
	210-0840-00			2	WASHER, .390 ID x 7/16 inch OD
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
9	366-0044-00	7000	10999	1	KNOB, SOURCE, small black
	366-0113-00	11000		1	KNOB, SOURCE, small charcoal
	-----			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
10	366-0038-00			1	KNOB, VARIABLE, small red
	-----			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
11	366-0058-00	7000	10999	1	KNOB, TIME/CM, large black
	366-0144-00	11000		1	KNOB, TIME/CM, large charcoal
	-----			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
12	-----			-	Mounting Hardware For Pot
	358-0010-00			1	BUSHING, panel
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-0494-00			1	NUT, hex, 3/8-32 x 11/16 inch
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0207-00			1	LUG, solder, 3/8 inch
13	129-0036-00	7000	10999	2	POST, binding, black
	129-0063-00	11000		2	POST, binding, charcoal
	-----			-	Mounting Hardware For Each: (not included)
	358-0036-00	7000	10999	1	BUSHING, binding post, black
	358-0169-00	11000		1	BUSHING, binding post, charcoal
	210-0010-00			1	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex, 10-32 x 3/8 inch

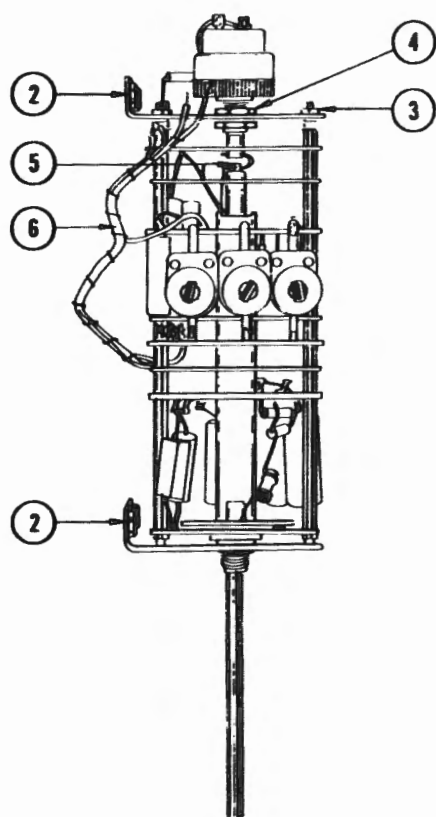
EXPLODED VIEW (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
14	129-0051-00			1	POST, binding, assembly
	- - - - -			-	Consisting of:
	355-0507-00			1	STEM, adapter
	200-0182-00			1	CAP
	- - - - -			-	Mounting Hardware: (not included)
	210-0223-00			1	LUG, solder, 1/4 inch
	210-0455-00			1	NUT, hex, 1/4-28 x 3/8 inch
15	358-0029-00			1	BUSHING, panel, 3/8-32 threads
16	131-0106-00			1	CONNECTOR, chassis mounted, 1 contact, BNC
	- - - - -			-	Includes:
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
17	352-0008-00	7000	11409	1	HOLDER, neon bulb, single, black
	352-0067-00	11410		1	HOLDER, neon bulb, single, gray
	- - - - -			-	Mounting Hardware: (not included)
	211-0031-00	7000	11409	1	SCREW, 4-40 x 1 inch FHS
	211-0109-00	11410		1	SCREW, 4-40 x 7/8 inch FHS
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
18	348-0006-00			2	GROMMET, 3/4 inch
19	136-0015-00			8	SOCKET, STM9G
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
20	136-0161-00	7000	8879	3	SOCKET, 3 pin transistor
	136-0181-00	8880	10999X	3	SOCKET, 3 pin transistor
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0113-00	7000	8879	2	SCREW, thread forming, 2-32 x 5/16 inch PHS phillips
	354-0234-00	8880	10999X	1	RING, locking, transistor socket
21	136-0095-00	7000	8879	1	SOCKET, 4 pin transistor
	136-0181-00	8880		1	SOCKET, 3 pin transistor
	- - - - -			-	Mounting Hardware: (not included)
	213-0113-00	7000	8879	2	SCREW, thread forming, 2-32 x 5/16 inch PHS phillips
	354-0234-00	8880		1	RING, locking, transistor socket
22	210-0202-00	7000	10999X	1	LUG, solder, SE 6
23	348-0004-00			1	GROMMET, 3/8 inch
24	348-0031-00			3	GROMMET, poly. snap-in
25	352-0065-00	7000	10999X	1	HOLDER, toroid
	- - - - -			-	Mounting Hardware: (not included)
	361-0039-00			1	SPACER, nylon, 1 1/32 inch
26	426-0121-00	7000	10999X	1	MOUNT, toroid
	- - - - -			-	Mounting Hardware: (not included)
	361-0007-00			1	SPACER, nylon, .063 inch
27	200-0536-00	7000	10999X	1	CAP, toroid
28	348-0023-00			4	FOOT, white nylon
29	136-0008-00			3	SOCKET, STM7G
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 PHS phillips

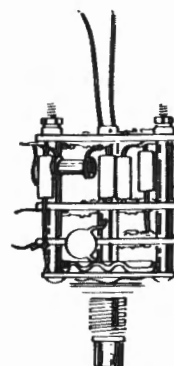
EXPLODED VIEW (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
30	441-0519-00	7000	10999	1	CHASSIS
	441-0519-01	11000		1	CHASSIS
	- - - - -			-	Mounting Hardware: (not included)
	211-0559-00			3	SCREW, 6-32 x $\frac{3}{8}$ inch FHS phillips
	211-0510-00			2	SCREW, 6-32 x $\frac{3}{8}$ inch BHS
	210-0006-00			5	LOCKWASHER, internal, #6
	210-0407-00			5	NUT, hex, 6-32 x $\frac{1}{4}$ inch
31	131-0096-00			1	CONNECTOR, chassis mounted, 32 contact
	- - - - -			-	Mounting Hardware: (not included)
	211-0011-00			2	SCREW, 4-40 x $\frac{5}{16}$ inch BHS
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0201-00			1	LUG, solder, SE 4
	210-0406-00			2	NUT, hex., 4-40 x $\frac{3}{16}$ inch
32	- - - - -			-	Mounting Hardware For Capacitor:
	210-0407-00			4	NUT, hex., 6-32 x $\frac{1}{4}$ inch
33	387-0570-00			1	PLATE, rear frame
	- - - - -			-	Mounting Hardware: (not included)
	212-0044-00			2	SCREW, 8-32 x $\frac{1}{2}$ inch RHS phillips
34	179-0811-00			1	CABLE, harness, coaxial
35	124-0091-00			12	STRIP, ceramic, $\frac{3}{4}$ inch x 11 notches
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0008-00			2	SPACER, nylon, .188 inch
36	179-0810-00	7000	10999	1	CABLE, harness, chassis
	179-0810-01	11000		1	CABLE, harness, chassis
37	124-0146-00	7000	10999X	2	STRIP, ceramic, $\frac{7}{16}$ inch x 16 notches
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, .313 inch
38	343-0089-00			4	CLAMP, cable, size D
39	384-0566-00	7000	7419	2	ROD, frame, spacing
	384-0615-00	7420		2	ROD, frame, spacing
	- - - - -			-	Mounting Hardware For Each: (not included)
	212-0043-00	7000	8819X	1	SCREW, 8-32 x $\frac{1}{2}$ inch FHS phillips
40	- - - - -	X11000		1	RESISTOR
	- - - - -			-	Mounting Hardware: (not included w/resistor)
	211-0544-00			1	SCREW, 6-32 x $\frac{3}{4}$ inch THS
	210-0478-00			1	NUT, hex, resistor mounting
	211-0507-00			1	SCREW, 6-32 x $\frac{5}{16}$ inch PHS
41	670-0098-00	X11000		1	ASSEMBLY, time base trigger circuit board
	- - - - -			-	assembly includes:
	388-0694-00	X11000		1	BOARD, circuit
	136-0220-00	X11000		3	SOCKET, 3 pin transistor
	426-0121-00	X11000		1	MOUNT, toroid
	361-0007-00	X11000		1	SPACER, nylon
	- - - - -			-	Mounting Hardware: (not included w/assembly)
	211-0601-00			1	SCREW, sems, 6-32 x $\frac{5}{16}$ inch PHS
	210-0801-00	X11160		1	WASHER, 5s x $\frac{9}{16}$ inch
	385-0146-00			2	ROD, hex
	211-0534-00			3	SCREW, 6-32 x $\frac{5}{16}$ inch PHS w/lockwasher
42	378-0541-00	X11410		1	FILTER, lens, neon

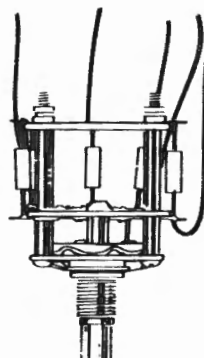
SWITCHES



① TIME/CM



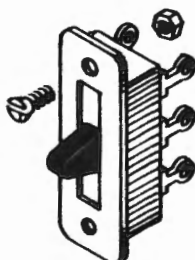
⑧ SWEEP FUNCTION



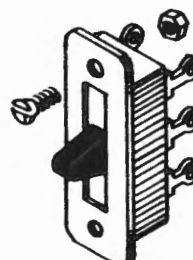
⑦ SOURCE



① RESET



⑩ COUPLING

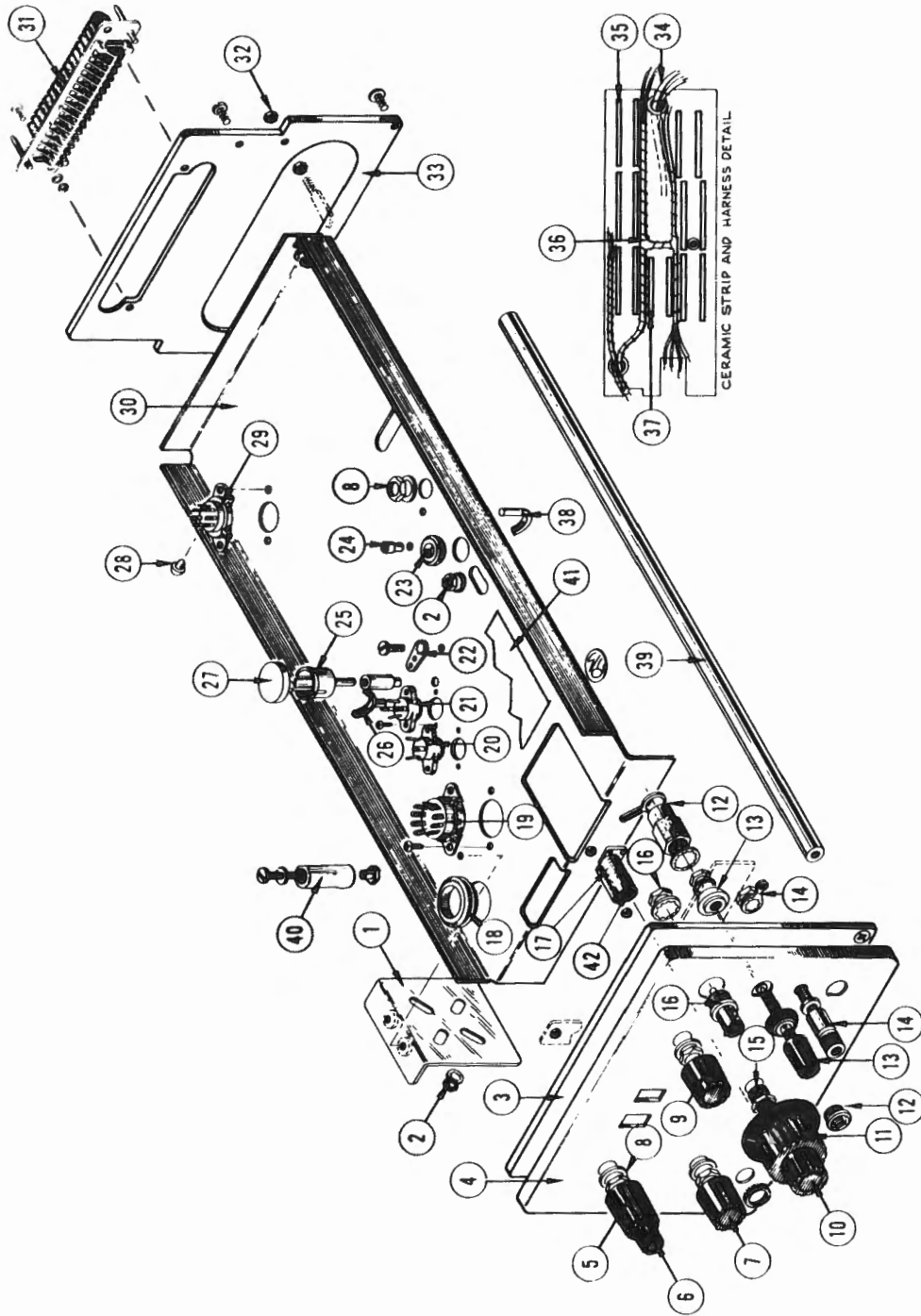


⑪ SLOPE

SWITCHES

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	262-0575-00			1	SWITCH, TIME/CM, wired
	260-0275-00			-	Includes:
2	406-0945-00			1	SWITCH, unwired
	211-0504-00			2	BRACKET, switch
3	210-0449-00			-	Mounting Hardware For Each: (not included)
	210-0017-00			2	SCREW, 6-32 x 1/4 inch BHS
	210-0202-00			2	NUT, hex, 5-40 x 1/4 inch
4	210-0413-00			1	LOCKWASHER, internal, #5
	210-0012-00			1	LUG, solder, SE 6
	210-0840-00			3	NUT, hex., 3/8-32 x 1/2 inch
5	384-0183-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	376-0014-00			1	WASHER, .390 ID x 7/16 inch OD
6	179-0812-00			1	ROD, extension
	358-0029-00			1	COUPLING, pot, wire
	210-0413-00			1	CABLE, harness, switch
				-	Mounting Hardware: (not included)
				1	BUSHING, panel, 3/8-32 thread
				1	NUT, hex., 3/8-32 x 1/2 inch
7	262-0578-00			1	SWITCH, SOURCE, wired
	260-0558-00			-	Includes:
	210-0413-00			1	SWITCH, unwired
	210-0840-00			-	Mounting Hardware: (not included)
	210-0012-00			1	NUT, hex., 3/8-32 x 1/2 inch
				1	WASHER, .390 ID x 7/16 inch OD
				1	LOCKWASHER, internal, 3/8 x 1/2 inch
8	262-0574-00	7000	10999	1	SWITCH, SWEEP FUNCTION, wired
	262-0574-01	11000		1	SWITCH, SWEEP FUNCTION, wired
	260-0557-00			-	Includes:
	210-0413-00			1	SWITCH, unwired
	210-0840-00			-	Mounting Hardware (not included)
	210-0012-00			1	NUT, hex., 3/8-32 x 1/2 inch
				1	WASHER, .390 ID x 7/16 inch OD
				1	LOCKWASHER, internal, 3/8 x 1/2 inch
9	260-0518-00			1	SWITCH, RESET, push button w/red indicator light
	210-0012-00			-	Mounting Hardware: (not included w/switch)
	210-0978-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0590-00			1	WASHER, 3/8 ID x 1/2 inch OD
10	260-0145-00	7000	10999	1	NUT, hex, 3/8-32 x 7/16 inch
	260-0449-00	11000		1	SWITCH, COUPLING, slide
	210-0406-00			1	SWITCH, COUPLING, slide
				-	Mounting Hardware: (not included)
				2	NUT, hex., 4-40 x 3/16 inch
11	260-0212-00	7000	10999	1	SWITCH, SLOPE, slide
	260-0447-00	11000		1	SWITCH, SLOPE, slide
	210-0406-00			-	Mounting Hardware: (not included)
				2	NUT, hex., 4-40 x 3/16 inch

EXPLODED VIEW



EXPLODED VIEW

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	406-0944-00 406-0944-01 ----- 211-0504-00	7000 11000	10999	1 1 - 2	BRACKET, pot mounting BRACKET, pot mounting Mounting Hardware: (not included) SCREW, 6-32 x 1/4 inch BHS
2	----- 210-0583-00 210-0046-00			- 5 5	Mounting Hardware For Small Pots: NUT, hex, 1/4-32 x 5/16 inch LOCKWASHER, internal, .400 OD x .261 inch ID
3	387-0823-00			1	PLATE, front sub-panel
4	333-0774-00			1	PANEL, front
5	366-0257-00 366-0332-00 ----- 213-0004-00	7000 11000	10999	1 1 - 1	KNOB, LEVEL, small black KNOB, LEVEL, small charcoal Includes: SCREW, set, 6-32 x 3/16 inch HSS
6	366-0255-00 ----- 213-0020-00			1 - 1	KNOB, VERNIER, small red Includes: SCREW, set, 6-32 x 1/8 inch HSS
7	366-0044-00 366-0113-00 ----- 213-0004-00	7000 11000	10999	1 1 - 1	KNOB, SWEEP FUNCTION, small black KNOB, SWEEP FUNCTION, small charcoal Includes: SCREW, set, 6-32 x 3/16 inch HSS
8	----- 210-0413-00 210-0840-00 210-0012-00			- 2 2 1	Mounting Hardware For Pots: NUT, hex, 3/8-32 x 1/2 inch WASHER, .390 ID x 3/16 inch OD LOCKWASHER, internal, 3/8 x 1/2 inch
9	366-0044-00 366-0113-00 ----- 213-0004-00	7000 11000	10999	1 1 - 1	KNOB, SOURCE, small black KNOB, SOURCE, small charcoal Includes: SCREW, set, 6-32 x 3/16 inch HSS
10	366-0038-00 ----- 213-0004-00			1 - 1	KNOB, VARIABLE, small red Includes: SCREW, set, 6-32 x 3/16 inch HSS
11	366-0058-00 366-0144-00 ----- 213-0004-00	7000 11000	10999	1 1 - 1	KNOB, TIME/CM, large black KNOB, TIME/CM, large charcoal Includes: SCREW, set, 6-32 x 3/16 inch HSS
12	----- 358-0010-00 210-0013-00 210-0494-00 210-0012-00 210-0207-00			- 1 1 1 1 1	Mounting Hardware For Pot: BUSHING, panel LOCKWASHER, internal, 3/8-32 x 1 1/16 inch NUT, hex, 3/8-32 x 1/2 x 1 1/16 inch LOCKWASHER, internal, 3/8 x 1/2 inch LUG, solder, 3/8 inch
13	129-0036-00 129-0063-00 ----- 358-0036-00 358-0169-00 210-0010-00 210-0445-00	7000 11000 7000 11000	10999 10999	2 2 - 1 1 1 1	POST, binding, black POST, binding, charcoal Mounting Hardware For Each: (not included) BUSHING, binding post, black BUSHING, binding post, charcoal LOCKWASHER, internal, #10 NUT, hex, 10-32 x 3/8 inch

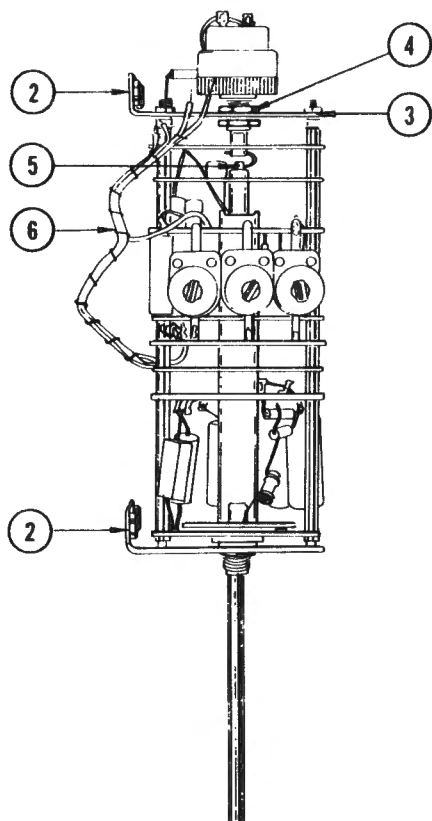
EXPLODED VIEW (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
14	129-0051-00			1	POST, binding, assembly
	355-0507-00			-	Consisting Of:
	200-0182-00			1	STEM, adapter
				1	CAP
	210-0223-00			-	Mounting Hardware: (not included)
	210-0455-00			1	LUG, solder, 1/4 inch
15	358-0029-00			1	NUT, hex, 1/4-28 x 3/8 inch
16	131-0106-00			1	BUSHING, panel 3/8-32 threads
				1	CONNECTOR, chassis mounted, 1 contact, BNC
	210-0413-00			-	Includes:
	210-0012-00			1	NUT, hex, 3/8-32 x 1/2 inch
17	352-0008-00	7000	11409	1	LOCKWASHER, internal, 3/8 x 1/2 inch
	352-0067-00	11410		1	HOLDER, neon bulb, single, black
				1	HOLDER, neon bulb, single, gray
	211-0031-00	7000	11409	-	Mounting Hardware: (not included)
	211-0109-00	11410		1	SCREW, 4-40 x 1 inch FHS
	210-0406-00			1	SCREW, 4-40 x 7/8 inch FHS
18	348-0006-00			2	NUT, hex, 4-40 x 3/16 inch
19	136-0015-00			2	GROMMET, 3/4 inch
				8	SOCKET, STM9G
	213-0044-00			-	Mounting Hardware For Each: (not included)
				2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
20	136-0161-00	7000	8889	3	SOCKET, 3 pin transistor
	136-0181-00	8890	10999X	3	SOCKET, 3 pin transistor
	213-0113-00	7000	8889	-	Mounting Hardware For Each: (not included)
	354-0234-00	8890	10999X	2	SCREW, thread forming, 2-32 x 5/16 inch PHS phillips
21	136-0095-00	7000	8889	1	RING, locking, transistor socket
	136-0181-00	8890		1	SOCKET, 4 pin transistor
	213-0113-00	7000	8889	1	SOCKET, 3 pin transistor
	354-0234-00	8890		-	Mounting Hardware: (not included)
22	210-0202-00	7000	10999X	2	SCREW, thread forming, 2-32 x 5/16 inch PHS phillips
23	348-0004-00			1	RING, locking, transistor socket
24	348-0031-00			1	LUG, solder, SE6
25	352-0065-00	7000	10999X	1	GROMMET, 3/8 inch
	361-0039-00			3	GROMMET, poly. snap-in
26	426-0121-00	7000	10999X	1	HOLDER, toroid
	361-0007-00			-	Mounting Hardware: (not included)
27	200-0536-00	7000	10999X	1	SPACER, nylon, .063 inch
28	348-0023-00			1	MOUNT, toroid
29	136-0008-00			1	Mounting Hardware: (not included)
	213-0044-00			1	SPACER, nylon, .063 inch
				1	CAP, toroid
				4	FOOT, white nylon
				4	SOCKET, STM7G
				-	Mounting Hardware For Each: (not included)
				2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips

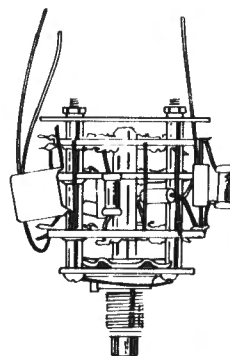
EXPLODED VIEW (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
30	441-0519-00	7000	10999	1	CHASSIS
	441-0519-01	11000		1	CHASSIS
	- - - - -			-	Mounting Hardware: (not included)
	211-0559-00			3	SCREW, 6-32 x $\frac{3}{8}$ inch FHS phillips
	211-0510-00			2	SCREW, 6-32 x $\frac{3}{8}$ inch BHS
	210-0006-00			5	LOCKWASHER, internal, #6
	210-0407-00			5	NUT, hex, 6-32 x $\frac{1}{4}$ inch
31	131-0096-00			1	CONNECTOR, chassis mounted, 32 contact
	- - - - -			-	Mounting Hardware: (not included)
	211-0011-00			2	SCREW, 4-40 x $\frac{5}{16}$ inch BHS
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0201-00			1	LUG, solder, SE 4
	210-0406-00			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch
32	- - - - -			-	Mounting Hardware For Capacitor:
	210-0407-00			4	NUT, hex, 6-32 x $\frac{1}{4}$ inch
33	387-0570-00			1	PLATE, rear frame
	- - - - -			-	Mounting Hardware: (not included)
	212-0044-00			2	SCREW, 8-32 x $\frac{1}{2}$ inch RHS phillips
34	179-0814-00	7000	10999	1	CABLE, harness, coaxial
	179-0814-01	11000		1	CABLE, harness, coaxial
35	124-0091-00			12	STRIP, ceramic, $\frac{3}{4}$ inch x 11 notches
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0008-00			2	SPACER, nylon, .188 inch
36	179-0813-00	7000	10999	1	CABLE, harness, chassis
	179-0813-01	11000		1	CABLE, harness, chassis
37	124-0146-00	7000	10999X	2	STRIP, ceramic, $\frac{7}{16}$ inch x 16 notches
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon .313 inch
38	343-0089-00			4	CLAMP, cable, size D
39	384-0566-00	7000	7419	2	ROD, frame, spacing
	384-0615-00	7420		2	ROD, frame, spacing
	- - - - -			-	Mounting Hardware For Each: (not included)
	212-0043-00	7000	8829X	1	SCREW, 8-32 x $\frac{1}{2}$ inch FHS phillips
40	- - - - -	X11000		1	RESISTOR
	- - - - -			-	Mounting Hardware: (not included w/resistor)
	211-0544-00			1	SCREW, 6-32 x $\frac{3}{4}$ inch THS
	210-0478-00			1	NUT, hex, resistor mounting
	211-0507-00			1	SCREW, 6-32 x $\frac{5}{16}$ inch PHS
41	670-0098-00	X11000		1	ASSEMBLY, time base trigger circuit board
	- - - - -			-	assembly includes:
	388-0694-00	X11000		1	BOARD, circuit
	136-0220-00	X11000		3	SOCKET, 3 pin transistor
	426-0121-00	X11000		1	MOUNT, toroid
	361-0007-00	X11000		1	SPACER, nylon
	- - - - -			-	Mounting Hardware: (not included w/assembly)
	211-0601-00			1	SCREW, sems, 6-32 x $\frac{5}{16}$ inch PHS
	210-0801-00	X11160		1	WASHER, 5s x $\frac{7}{16}$ inch
	385-0146-00			2	ROD, hex
	211-0534-00			3	SCREW, 6-32 x $\frac{5}{16}$ inch PHS w/lockwasher
42	378-0541-00	X11410		1	FILTER, lens, neon

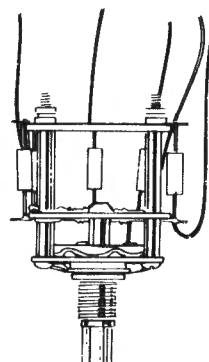
SWITCHES



1 TIME/CM



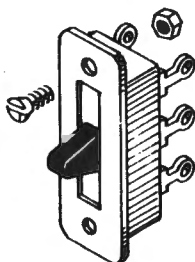
8 SWEEP FUNCTION



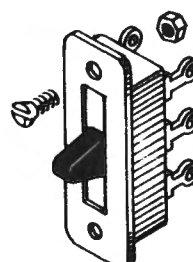
7 SOURCE



9 RESET



10 COUPLING



11 SLOPE

SWITCHES

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	262-0577-00			1	SWITCH, TIME/CM, wired
	- - - - -			-	Includes:
	260-0275-00			1	SWITCH, unwired
2	406-0945-00			2	BRACKET, switch
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch
3	210-0449-00			2	NUT, hex, 5-40 x 1/4 inch
	210-0017-00			1	LOCKWASHER, internal, #5
	210-0202-00			1	LUG, solder, SE 6
4	210-0413-00			3	NUT, hex, 3/8-32 x 1/2 inch
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 7/16 inch OD
5	384-0183-00			1	ROD, extension
	376-0014-00			1	COUPLING, pot, wire
6	179-0815-00			1	CABLE, harness, switch
	- - - - -			-	Mounting Hardware: (not included)
	358-0029-00			1	BUSHING, panel, 3/8-32 thread
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
7	262-0578-00			1	SWITCH, SOURCE, wired
	- - - - -			-	Includes:
	260-0558-00			1	SWITCH, unwired
	- - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 7/16 inch OD
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
8	262-0628-00	7000	10999	1	SWITCH, SWEEP FUNCTION, wired
	262-0628-01	11000		1	SWITCH, SWEEP FUNCTION, wired
	- - - - -			-	Includes:
	260-0556-00			1	SWITCH, unwired
	- - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 7/16 inch OD
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
9	260-0518-00			1	SWITCH, RESET, push button w/red indicator light
	- - - - -			-	Mounting Hardware: (not included w/switch)
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0978-00			1	WASHER, 3/8 ID x 1/2 inch OD
	210-0590-00			1	NUT, hex, 3/8-32 x 7/16 inch
10	260-0145-00	7000	10999	1	SWITCH, COUPLING, slide
	260-0449-00	11000		1	SWITCH, COUPLING, slide
	- - - - -			-	Mounting Hardware: (not included)
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
11	260-0212-00	7000	10999	1	SWITCH, SLOPE, slide
	260-0447-00	11000		1	SWITCH, SLOPE, slide
	- - - - -			-	Mounting Hardware: (not included)
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch



ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range
Bulbs			
B364	Use 150-027	Neon, NE-23	
B384	Use 150-027	Neon, NE-23	
B395	Use 150-027	Neon, NE-23	7000-11279
B395	150-0030-00	Neon, NE-2V	11280-up
B396	Use 150-027	Neon, NE-23	7000-11279
B396	150-0030-00	Neon, NE-2V	11280-up
B464	Use 150-027	Neon, NE-23	
B484	Use 150-027	Neon, NE-23	
B495	Use 150-027	Neon, NE-23	7000-11279
B495	150-0030-00	Neon, NE-2V	11280-up
B496	Use 150-027	Neon, NE-23	7000-11279
B496	150-0030-00	Neon, NE-2V	11280-up
B601	150-001	Incandescent, #47	
B602	150-001	Incandescent, #47	7000-8999
	150-031	Incandescent, #44	9000-up
B603	150-001	Incandescent, #47	7000-8999
B603	150-031	Incandescent, #44	9000-up
B1083	Use 150-027	Neon, NE-23	7000-11279
B1083	150-0030-00	Neon, NE-2V	11280-up
B1227	Use 150-027	Neon, NE-23	7000-11279
B1227	150-0030-00	Neon, NE-2V	11280-up
B2083	Use 150-027	Neon, NE-23	7000-11279
B2083	150-0030-00	Neon, NE-2V	11280-up
B2227	Use 150-027	Neon, NE-23	7000-11279
B2227	150-0030-00	Neon, NE-2V	11280-up

Capacitors

Tolerance $\pm 20\%$ unless otherwise indicated.

Tolerance of all electrolytic capacitors as follows (with exceptions):

3 V — 50 V = -10% , $+250\%$ 51 V — 350 V = -10% , $+100\%$ 351 V — 450 V = -10% , $+50\%$

C306C	281-012	7-45 pf	Cer	Var		
C306E	Use 283-0518-00	330 pf	Mica		500 v	10%
C322	283-001	.005 μ f	Disc Type		500 v	
C330	281-010	4.5-25 pf	Cer	Var		
C331	283-001	.005 μ f	Disc Type		500 v	
C340	281-501	4.7 pf	Cer		500 v	± 1 pf
C350	281-005	1.5-7 pf	Cer	Var		
C355	281-526	1.5 pf	Cer		500 v	± 0.5 pf
C364	281-011	5-25 pf	Cer	Var		
C372	281-023	9-180 pf	Mica	Var		
C380	290-000	6.25 μ f	EMT		300 v	
C384	281-011	5-25 pf	Cer	Var		
C390	283-010	.05 μ f	Disc Type		50 v	
C392	281-501	4.7 pf	Cer		500 v	± 1 pf
C394	283-001	.005 μ f	Disc Type		500 v	

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
C406C	281-012	7-45 pf Cer	10%
C406E	Use 283-0518-00	330 pf Mica	
C422	283-001	.005 μ f Disc Type	
C430	281-010	4.5-25 pf Cer	
C431	283-001	.005 μ f Disc Type	
C440	281-501	4.7 pf Cer	± 1 pf
C450	281-005	1.5-7 pf Cer	
C455	281-526	1.5 pf Cer	
C464	281-011	5-25 pf Cer	
C472	281-023	9-180 pf Mica	
C480	290-000	6.25 μ f EMT	300 v
C484	281-011	5-25 pf Cer	
C490	283-010	.05 μ f Disc Type	
C492	281-501	4.7 pf Cer	
C494	283-001	.005 μ f Disc Type	
C512	283-006	.02 μ f Disc Type	500 v
C520	283-001	.005 μ f Disc Type	
C523	281-506	12 pf Cer	
C530	283-001	.005 μ f Disc Type	
C533	281-506	12 pf Cer	
C561	283-002	.01 μ f Disc Type	500 v
C565	283-001	.005 μ f Disc Type	
C584	281-513	27 pf Cer	
C594	281-518	47 pf Cer	
C597	283-001	.005 μ f Disc Type	
C601	283-004	.02 μ f Disc Type	150 v
C610	285-510	.01 μ f MT	
C618	285-510	.01 μ f MT	
C628	285-510	.01 μ f MT	
C640	Use 290-0016-00	125 μ f EMC	
C649	Use 290-0012-00	2 x 40 μ f EMC	250 v
C650	285-510	.01 μ f MT	
C671	Use 290-0078-00	2 x 200 μ f EMC	
C682	285-510	.01 μ f MT	
C688	285-510	.01 μ f MT	
C700	Use 290-0017-00	125 μ f EMC	450 v
C710	285-511	.01 μ f PTM	
C730	Use 290-0077-00	2 x 100 μ f EMC	
C731	Use 290-0077-00	2 x 100 μ f EMC	
C740	285-510	.01 μ f MT	
C760A,B	Use 290-0013-00	2 x 40 μ f EMC	450 v
C771	Use 290-0010-00	2 x 20 μ f EMC	
C773	Use 290-0010-00	2 x 20 μ f EMC	
C775A,B,C	Use 290-0005-00	3 x 10 μ f EMC	
C776A,B	Use 290-0006-00	2 x 15 μ f EMC	
C778A,B	Use 290-0006-00	2 x 15 μ f EMC	350 v
C780	Use 290-0006-00	2 x 15 μ f EMC	
C784	290-000	6.25 μ f EMC	
C785	Use 290-0006-00	2 x 15 μ f EMC	
C793	285-540	1 μ f PTM	

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
C803	Use 283-0000-00	.001 μ f	Cer	500 v	
C806	285-510	.01 μ f	MT	400 v	
C808	285-502	.001 μ f	MT	1000 v	
C819	283-057	.1 μ f	Disc Type	200 v	
C820	283-011	.01 μ f	Disc Type	2000 v	
C821	283-011	.01 μ f	Disc Type	2000 v	
C827	283-011	.01 μ f	Disc Type	2000 v	
C828	283-011	.01 μ f	Disc Type	2000 v	
C831	283-011	.01 μ f	Disc Type	2000 v	
C842	285-519	.047 μ f	MT	400 v	
C843	283-011	.01 μ f	Disc Type	2000 v	
C844	283-011	.01 μ f	Disc Type	2000 v	
C848	283-011	.01 μ f	Disc Type	2000 v	
C871	283-518	330 pf	Mica	500 v	10%
C874	283-518	330 pf	Mica	500 v	10%
C885	281-513	27 pf	Cer	500 v	
C897	283-000	.001 μ f	Disc Type	500 v	
C903	285-501	.001 μ f	MT	600 v	
C906	285-510	.01 μ f	MT	400 v	
C908	285-502	.001 μ f	MT	1000 v	
C919	283-057	.1 μ f	Disc Type	200 v	
C920	283-011	.01 μ f	Disc Type	2000 v	
C921	283-011	.01 μ f	Disc Type	2000 v	
C927	283-011	.01 μ f	Disc Type	2000 v	
C928	283-011	.01 μ f	Disc Type	2000 v	
C931	283-011	.01 μ f	Disc Type	2000 v	
C932	283-018	.001 μ f	Disc Type	6000 v	
C933	281-556	500 pf	Cer	10,000 v	
C935	281-556	500 pf	Cer	10,000 v	
C942	285-519	.047 μ f	MT	400 v	
C943	283-011	.01 μ f	Disc Type	2000 v	
C944	283-011	.01 μ f	Disc Type	2000 v	
C948	283-011	.01 μ f	Disc Type	2000 v	
C1003	Use 290-0010-00	2 x 20 μ f	EMC	450 v	
C1005A,B,C	Use 290-0062-00	10 x 20 x 40 μ f	EMC	475 v	
C1007	285-526	.1 μ f	MT	400 v	
C1013	283-001	.005 μ f	Disc Type	500 v	
C1029	283-000	.001 μ f	Disc Type	500 v	
C1031	283-001	.005 μ f	Disc Type	500 v	
C1039	281-536	.001 μ f	Cer	500 v	10%
C1043	283-001	.005 μ f	Disc Type	500 v	
C1049	281-536	.001 μ f	Cer	500 v	10%
C1052	283-000	.001 μ f	Disc Type	500 v	
C1054	283-001	.005 μ f	Disc Type	500 v	
C1056	281-524	150 pf	Cer	500 v	

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
C1062	283-000	.001 μ f	Disc	Type	500 v
C1075	281-022	8-50 pf	Cer	Var	
C1077	281-022	8-50 pf	Cer	Var	
C1078	281-027	7-3 pf	Tub.	Var	
C1085	283-001	.005 μ f	Disc	Type	500 v
C1093A,B,C,D	Use 290-0070-00	4 x 75 μ f	EMC		150 v
C1102	283-000	.001 μ f	Disc	Type	500 v
C1104	281-027	7-3 pf	Tub.	Var	
C1105	281-524	150 pf	Cer		500 v
C1106	281-524	150 pf	Cer		500 v
C1112	283-000	.001 μ f	Disc	Type	500 v
C1122	283-000	.001 μ f	Disc	Type	500 v
C1124	281-027	7-3 pf	Tub.	Var	
C1126	281-524	150 pf	Cer		500 v
C1132	283-000	.001 μ f	Disc	Type	500 v
C1142	283-000	.001 μ f	Disc	Type	500 v
C1144	281-027	7-3 pf	Tub.	Var	
C1146	281-524	150 pf	Cer		500 v
C1152	283-000	.001 μ f	Disc	Type	500 v
C1162	283-000	.001 μ f	Disc	Type	500 v
C1164	281-027	7-3 pf	Tub.	Var	
C1166	281-524	150 pf	Cer		500 v
C1172	283-000	.001 μ f	Disc	Type	500 v
C1182	283-000	.001 μ f	Disc	Type	500 v
C1184	281-027	7-3 pf	Tub.	Var	
C1186	281-524	150 pf	Cer		500 v
C1192	283-000	.001 μ f	Disc	Type	500 v
C1202	283-000	.001 μ f	Disc	Type	500 v
C1204	281-027	7-3 pf	Tub.	Var	
C1205	281-524	150 pf	Cer		500 v
C1208	283-001	.005 μ f	Disc	Type	500 v
C1212	283-000	.001 μ f	Disc	Type	500 v
C1223	283-000	.001 μ f	Disc	Type	500 v
C1228	283-001	.005 μ f	Disc	Type	500 v
C1301	281-0037-00	7-3 pf	Tub.	Var	
C1302	281-0037-00	7-3 pf	Tub.	Var	
C1303	281-0037-00	7-3 pf	Tub.	Var	
C1304	281-0037-00	7-3 pf	Tub.	Var	
C1305	281-0037-00	7-3 pf	Tub.	Var	
C1306	281-0037-00	7-3 pf	Tub.	Var	
C1307	281-0037-00	7-3 pf	Tub.	Var	
C1308	281-0037-00	7-3 pf	Tub.	Var	
C1309	281-0037-00	7-3 pf	Tub.	Var	
C1310	281-0037-00	7-3 pf	Tub.	Var	
C1311	281-0037-00	7-3 pf	Tub.	Var	

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.		Description	S/N Range
C1312	281-0037-00	.7-3 pf	Tub.	Var
C1313	281-0037-00	.7-3 pf	Tub.	Var
C1314	281-0037-00	.7-3 pf	Tub.	Var
C1315	281-0037-00	.7-3 pf	Tub.	Var
C1316	281-0037-00	.7-3 pf	Tub.	Var
C1317	281-0037-00	.7-3 pf	Tub.	Var
C1318	281-0037-00	.7-3 pf	Tub.	Var
C1319	281-0037-00	.7-3 pf	Tub.	Var
C1320	281-0037-00	.7-3 pf	Tub.	Var
C1321	281-0037-00	.7-3 pf	Tub.	Var
C1322	281-0037-00	.7-3 pf	Tub.	Var
C1323	281-0037-00	.7-3 pf	Tub.	Var
C1324	281-0037-00	.7-3 pf	Tub.	Var
C1325	281-0037-00	.7-3 pf	Tub.	Var
C1326	281-0037-00	.7-3 pf	Tub.	Var
C1327	281-0037-00	.7-3 pf	Tub.	Var
C1328	281-0037-00	.7-3 pf	Tub.	Var
C1329	281-0037-00	.7-3 pf	Tub.	Var
C1330	281-0037-00	.7-3 pf	Tub.	Var
C1331	281-0037-00	.7-3 pf	Tub.	Var
C1332	281-0037-00	.7-3 pf	Tub.	Var
C1333	281-0037-00	.7-3 pf	Tub.	Var
C1334	281-0037-00	.7-3 pf	Tub.	Var
C1335	281-0037-00	.7-3 pf	Tub.	Var
C1336	281-0037-00	.7-3 pf	Tub.	Var
C1337	281-0037-00	.7-3 pf	Tub.	Var
C1338	281-0037-00	.7-3 pf	Tub.	Var
C1339	281-0037-00	.7-3 pf	Tub.	Var
C1340	281-0037-00	.7-3 pf	Tub.	Var
C1341	281-0037-00	.7-3 pf	Tub.	Var
C1342	281-0037-00	.7-3 pf	Tub.	Var
C1343	281-0037-00	.7-3 pf	Tub.	Var
C1344	281-0037-00	.7-3 pf	Tub.	Var
C1345	281-0037-00	.7-3 pf	Tub.	Var
C1346	281-0037-00	.7-3 pf	Tub.	Var
C1347	281-0037-00	.7-3 pf	Tub.	Var
C1348	281-0037-00	.7-3 pf	Tub.	Var
C1349	281-0037-00	.7-3 pf	Tub.	Var
C1350	281-0037-00	.7-3 pf	Tub.	Var
C1359	281-0538-00	1 pf	Cer	500 v
C1360	281-0529-00	1.5 pf	Cer	500 v
C1361	281-0529-00	1.5 pf	Cer	500 v
C1362	281-0529-00	1.5 pf	Cer	500 v
C1363	281-0529-00	1.5 pf	Cer	500 v
C1364	281-0529-00	1.5 pf	Cer	500 v

±0.25 pf
±0.25 pf
±0.25 pf
±0.25 pf
±0.25 pf

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
C1365	281-529	1.5 pf	Cer	500 v	±0.25 pf
C1366	281-529	1.5 pf	Cer	500 v	±0.25 pf
C1367	281-529	1.5 pf	Cer	500 v	±0.25 pf
C1368	281-529	1.5 pf	Cer	500 v	±0.25 pf
C1369	281-529	1.5 pf	Cer	500 v	±0.25 pf
C1370	281-529	1.5 pf	Cer	500 v	±0.25 pf
C1371	281-529	1.5 pf	Cer	500 v	±0.25 pf
C1372	281-529	1.5 pf	Cer	500 v	±0.25 pf
C1373	281-529	1.5 pf	Cer	500 v	±0.25 pf
C1374	281-529	1.5 pf	Cer	500 v	±0.25 pf
C1375	281-529	1.5 pf	Cer	500 v	±0.25 pf
C1380	281-537	.68 pf	Cer	500 v	
C1381	281-537	.68 pf	Cer	500 v	
C1382	281-537	.68 pf	Cer	500 v	
C1383	281-537	.68 pf	Cer	500 v	
C1423	283-001	.005 μf	Disc Type	500 v	
C1424	283-001	.005 μf	Disc Type	500 v	
C1433	283-001	.005 μf	Disc Type	500 v	
C2003	Use 290-0010-00	2 x 20 μf	EMC	450 v	
C2005A,B,C	Use 290-0062-00	10 x 20 x 40 μf	EMC	475 v	
C2007	285-526	.1 μf	MT	400 v	
C2013	283-001	.005 μf	Disc Type	500 v	
C2029	283-000	.001 μf	Disc Type	500 v	
C2031	283-001	.005 μf	Disc Type	500 v	
C2039	281-536	.001 pf	Cer	500 v	10%
C2043	283-001	.005 μf	Disc Type	500 v	
C2049	281-536	.001 pf	Cer	500 v	10%
C2052	283-000	.001 μf	Disc Type	500 v	
C2054	283-001	.005 μf	Disc Type	500 v	
C2056	281-524	150 pf	Cer	500 v	
C2062	283-000	.001 pf	Disc Type	500 v	
C2075	281-022	8-50 pf	Cer	Var	
C2077	281-022	8-50 pf	Cer	Var	
C2078	281-027	.7-3 pf	Tub.	Var	
C2085	283-001	.005 μf	Disc Type	500 v	
C2093A,B,C,D	Use 290-0070-00	4 x 75 μf	EMC	150 v	
C2102	283-000	.001 μf	Disc Type	500 v	
C2104	281-027	.7-3 pf	Tub.	Var	
C2105	281-524	150 pf	Cer	500 v	
C2106	281-524	150 pf	Cer	500 v	
C2112	283-000	.001 μf	Disc Type	500 v	
C2122	283-000	.001 μf	Disc Type	500 v	
C2124	281-027	.7-3 pf	Tub.	Var	
C2126	281-524	150 pf	Cer	500 v	
C2132	283-000	.001 μf	Disc Type	500 v	

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.		Description	S/N Range
C2142	283-000	.001 μ f	Disc Type	500 v
C2144	281-027	.7-3 pf	Tub.	Var
C2146	281-524	150 pf	Cer	500 v
C2152	283-000	.001 μ f	Disc Type	500 v
C2162	283-000	.001 μ f	Disc Type	500 v
C2164	281-027	.7-3 pf	Tub.	Var
C2166	281-524	150 pf	Cer	500 v
C2172	283-000	.001 μ f	Disc Type	500 v
C2182	283-000	.001 μ f	Disc Type	500 v
C2184	281-027	.7-3 pf	Tub.	Var
C2186	281-524	150 pf	Cer	500 v
C2192	283-000	.001 μ f	Disc Type	500 v
C2202	283-000	.001 μ f	Disc Type	500 v
C2204	281-027	.7-3 pf	Tub.	Var
C2205	281-524	150 pf	Cer	500 v
C2208	283-001	.005 μ f	Disc Type	500 v
C2212	283-000	.001 μ f	Disc Type	500 v
C2223	283-000	.001 μ f	Disc Type	500 v
C2228	283-001	.005 μ f	Disc Type	500 v
C2301	281-0037-00	.7-3 pf	Tub.	Var
C2302	281-0037-00	.7-3 pf	Tub.	Var
C2303	281-0037-00	.7-3 pf	Tub.	Var
C2304	281-0037-00	.7-3 pf	Tub.	Var
C2305	281-0037-00	.7-3 pf	Tub.	Var
C2306	281-0037-00	.7-3 pf	Tub.	Var
C2307	281-0037-00	.7-3 pf	Tub.	Var
C2308	281-0037-00	.7-3 pf	Tub.	Var
C2309	281-0037-00	.7-3 pf	Tub.	Var
C2310	281-0037-00	.7-3 pf	Tub.	Var
C2311	281-0037-00	.7-3 pf	Tub.	Var
C2312	281-0037-00	.7-3 pf	Tub.	Var
C2313	281-0037-00	.7-3 pf	Tub.	Var
C2314	281-0037-00	.7-3 pf	Tub.	Var
C2315	281-0037-00	.7-3 pf	Tub.	Var
C2316	281-0037-00	.7-3 pf	Tub.	Var
C2317	281-0037-00	.7-3 pf	Tub.	Var
C2318	281-0037-00	.7-3 pf	Tub.	Var
C2319	281-0037-00	.7-3 pf	Tub.	Var
C2320	281-0037-00	.7-3 pf	Tub.	Var
C2321	281-0037-00	.7-3 pf	Tub.	Var
C2322	281-0037-00	.7-3 pf	Tub.	Var
C2323	281-0037-00	.7-3 pf	Tub.	Var
C2324	281-0037-00	.7-3 pf	Tub.	Var
C2325	281-0037-00	.7-3 pf	Tub.	Var
C2326	281-0037-00	.7-3 pf	Tub.	Var

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.		Description	S/N Range
C2327	281-0037-00	.7-3 pf	Tub. Var	
C2328	281-0037-00	.7-3 pf	Tub. Var	
C2329	281-0037-00	.7-3 pf	Tub. Var	
C2330	281-0037-00	.7-3 pf	Tub. Var	
C2331	281-0037-00	.7-3 pf	Tub. Var	
C2332	281-0037-00	.7-3 pf	Tub. Var	
C2333	281-0037-00	.7-3 pf	Tub. Var	
C2334	281-0037-00	.7-3 pf	Tub. Var	
C2335	281-0037-00	.7-3 pf	Tub. Var	
C2336	281-0037-00	.7-3 pf	Tub. Var	
C2337	281-0037-00	.7-3 pf	Tub. Var	
C2338	281-0037-00	.7-3 pf	Tub. Var	
C2339	281-0037-00	.7-3 pf	Tub. Var	
C2340	281-0037-00	.7-3 pf	Tub. Var	
C2341	281-0037-00	.7-3 pf	Tub. Var	
C2342	281-0037-00	.7-3 pf	Tub. Var	
C2343	281-0037-00	.7-3 pf	Tub. Var	
C2344	281-0037-00	.7-3 pf	Tub. Var	
C2345	281-0037-00	.7-3 pf	Tub. Var	
C2346	281-0037-00	.7-3 pf	Tub. Var	
C2347	281-0037-00	.7-3 pf	Tub. Var	
C2348	281-0037-00	.7-3 pf	Tub. Var	
C2349	281-0037-00	.7-3 pf	Tub. Var	
C2350	281-0037-00	.7-3 pf	Tub. Var	
C2359	281-538	1 pf	Cer	500 v
C2360	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2361	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2362	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2363	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2364	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2365	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2366	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2367	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2368	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2369	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2370	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2371	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2372	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2373	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2374	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2375	281-529	1.5 pf	Cer	500 v ± 0.25 pf
C2380	281-537	.68 pf	Cer	500 v
C2381	281-537	.68 pf	Cer	500 v
C2382	281-537	.68 pf	Cer	500 v
C2383	281-537	.68 pf	Cer	500 v

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.	Description			S/N Range
C2423	283-001	.005 μ f	Disc Type	500 v	
C2424	283-001	.005 μ f	Disc Type	500 v	
C2433	283-001	.005 μ f	Disc Type	500 v	

Diodes

D642A,B,C,D	152-047	Silicon 1N2862 (or equal)			7000-11559
D642A,B,C,D	152-0066-00	Silicon 1N3194			11560-up
D672A,B,C,D	152-050	Silicon 1N1566			
D702A,B	152-047	Silicon 1N2862 (or equal)			7000-11559
D702A,B	152-0066-00	Silicon 1N3194			11560-up
D722	152-047	Silicon 1N2862 (or equal)			7000-11559
D722	152-0066-00	Silicon 1N3194			11560-up
D732A,B	152-047	Silicon 1N2862 (or equal)			7000-11559
D732A,B	152-0066-00	Silicon 1N3194			11560-up
D762A,B,C,D	152-047	Silicon 1N2862 (or equal)			7000-11559
D762A,B,C,D	152-0066-00	Silicon 1N3194			11560-up

Fuses

F601	159-036	7 Amp 3AG Slo-Blo 117 v oper 50 & 60 cycle		
	159-027	4 Amp 3AG Slo-Blo 234 v oper 50 & 60 cycle		
F602	159-006	5 Amp 3AG Slo-Blo 117 v oper 50 & 60 cycle		
	159-005	3 Amp 3AG Slo-Blo 234 v oper 50 & 60 cycle		
F1054	159-049	.15 Amp Fast-Blo w/pigtail		
F2054	159-049	.15 Amp Fast-Blo w/pigtail		

Relays

K600	148-002	6 v 45 sec. Delay		
K601	148-011	6.3 v AC		

Inductors

L564	*108-015	255 μ h		
L790	*108-236	Saturable Reactor		
L973	*108-158	Beam Rotator		
L1014	*114-112	1.8-3.9 μ h	Var	Core 276-506
L1015	*108-062	.45 μ h		
L1024	*114-112	1.8-3.9 μ h	Var	Core 276-506
L1025	*108-062	.45 μ h		
L1033	276-507	Core, Ferramic Suppressor		
L1036	*114-111	.3-.55 μ h		
L1046	*114-111	.3-.55 μ h		
L1064	*108-157	8.4 μ h		
L1071	*114-092	.3-.5 μ h	Var	Core 276-506
L1073	*114-092	.3-.5 μ h	Var	Core 276-506
L1103	*108-145	Grid Line, 6 Section		
L1104	*108-139	Plate Line, 7 Section		

Inductors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range	
L1113	*108-145	Grid Line, 6 Section		
L1114	*108-139	Plate Line, 7 Section		
L1304	*108-177	Delay Line, 30 Section		
L1305	*108-177	Delay Line, 30 Section		
L1334	*108-176	Delay Line, 20 Section		
L1335	*108-176	Delay Line, 20 Section		
L1354	*114-038	.9-1.6 μ h	Var	Core 276-506
L1355	*114-038	.9-1.6 μ h	Var	Core 276-506
L1420	276-507	Core, Ferramic Suppressor		
L2014	*114-112	1.8-3.9 μ h	Var	Core 276-506
L2015	*108-062	.45 μ h		
L2024	*114-112	1.8-3.9 μ h	Var	Core 276-506
L2025	*108-062	Core, Ferramic Suppressor		
L2033	276-507	.45 μ h		
L2036	*114-111	.3-.55 μ h	Var	Core 276-506
L2046	*114-111	.3-.55 μ h	Var	Core 276-506
L2064	*108-157	8.4 μ h		
L2071	*114-092	.3-.5 μ h	Var	Core 276-506
L2073	*114-092	.3-.5 μ h	Var	Core 276-506
L2103	*108-145	Grid Line, 6 Section		
L2104	*108-139	Plate Line, 7 Section		
L2113	*108-145	Grid Line, 6 Section		
L2114	*108-139	Plate Line, 7 Section		
L2304	*108-177	Delay Line, 30 Section		
L2305	*108-177	Delay Line, 30 Section		
L2334	*108-176	Delay Line, 20 Section		
L2335	*108-176	Delay Line, 20 Section		
L2354	*114-038	.9-1.6 μ h	Var	Core 276-506
L2355	*114-038	.9-1.6 μ h	Var	Core 276-506
L2420	276-507	Core, Ferramic Suppressor		

Resistors

Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.

R306C	309-111	900 k	$\frac{1}{2}$ w	Prec.	1%
R306E	309-045	100 k	$\frac{1}{2}$ w	Prec.	1%
R311	302-102	1 k	$\frac{1}{2}$ w		
R313	306-333	33 k	2 w		
R315	Use 311-0571-00	15 k		Var	EXT. HORIZ. GAIN
R317	306-273	27 k	2 w		
R319	306-333	33 k	2 w		
R321	302-101	100 Ω	$\frac{1}{2}$ w		
R322	302-332	3.3 k	$\frac{1}{2}$ w		
R324	302-224	220 k	$\frac{1}{2}$ w		

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R326	311-026	100 k	EXT. HORIZ. AMP DC BAL.
R330	309-022	1.94 meg	Prec 1%
R331	309-268	12.1 meg	Prec 1% 7000-11599
R331	310-0069-00	13 meg	Prec 2% 11600-up
R332	309-414	5 meg	Prec 1%
R333†	311-425	120 k	HORIZ. POSITION
R334	302-103	10 k	
R335	306-333	33 k	
R336†	311-425	50 k	HORIZ. POSITION
R338	304-153	15 k	
R340	302-222	2.2 k	
R341	302-470	47 Ω	
R343	304-104	100 k	
R350	309-091	120 k	
R351	311-125	50 k	Prec 1% SWP. CAL.
R352	302-470	47 Ω	
R353	304-104	100 k	
R355	310-094	400 k	Prec 1%
R356	310-094	400 k	Prec 1%
R357	302-223	22 k	
R358	311-018	20 k	NOR./MAG. REGIS.
R361	302-470	47 Ω	
R364	*310-506	6-25 k	WW 1%
R366	302-470	47 Ω	
R372	311-071	2.25 k	
R374	304-222	2.2 k	MAG. GAIN
R375	304-222	2.2 k	
R376	308-112	6 k	WW 1%
R380	302-101	100 Ω	
R381	302-470	47 Ω	
R384	*310-507	6-30 k	WW 1%
R386	302-470	47 Ω	
R387	306-393	39 k	
R388	306-393	39 k	
R390	302-391	390 Ω	
R391	302-470	47 Ω	
R392	302-222	2.2 k	
R394	302-474	470 k	
R395	302-824	820 k	
R396	302-824	820 k	
R397	302-474	470 k	
R406C	309-111	900 k	Prec 1%
R406E	309-045	100 k	Prec 1%
R411	302-102	1 k	
R413	306-333	33 k	
R415	Use 311-0571-00	15 k	EXT. HORIZ. GAIN

†R333 and R336 furnished as a unit.

Parts List—Type 555

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R417	306-273	27 k	2 w
R419	306-333	33 k	2 w
R421	302-101	100 Ω	$\frac{1}{2}$ w
R422	302-332	3.3 k	$\frac{1}{2}$ w
R423	302-224	220 k	$\frac{1}{2}$ w
R426	311-026	100 k	Var
R430	309-022	1.94 meg	$\frac{1}{2}$ w
R431	309-268	12.1 meg	$\frac{1}{2}$ w
R431	310-0069-00	13 meg	1 w
R432	309-414	5 meg	$\frac{1}{2}$ w
R433†	311-425	120 k	Var
R434	302-103	10 k	$\frac{1}{2}$ w
R435	306-333	33 k	2 w
R436†	311-425	50 k	Var
R438	304-153	15 k	1 w
R440	302-222	2.2 k	$\frac{1}{2}$ w
R441	302-470	47 Ω	$\frac{1}{2}$ w
R443	304-104	100 k	1 w
R450	309-091	120 k	$\frac{1}{2}$ w
R451	311-125	50 k	.2 w
R452	302-470	47 Ω	$\frac{1}{2}$ w
R453	304-104	100 k	1 w
R455	310-094	400 k	1 w
R456	310-094	400 k	1 w
R457	302-223	22 k	$\frac{1}{2}$ w
R458	311-018	20 k	Var
R461	302-470	47 Ω	$\frac{1}{2}$ w
R464	*310-506	6-25	7 w
R466	302-470	47 Ω	$\frac{1}{2}$ w
R472	311-071	2.25 k	1 w
R474	304-222	2.2 k	1 w
R475	304-222	2.2 k	1 w
R476	308-112	6 k	5 w
R480	302-101	100 Ω	$\frac{1}{2}$ w
R481	302-470	47 Ω	$\frac{1}{2}$ w
R484	*310-507	6-30 k	7 w
R486	302-470	47 Ω	$\frac{1}{2}$ w
R487	306-393	39 k	2 w
R488	306-393	39 k	2 w
R490	302-391	390 Ω	$\frac{1}{2}$ w
R491	302-470	47 Ω	$\frac{1}{2}$ w
R492	302-222	2.2 k	$\frac{1}{2}$ w
R494	302-474	470 k	$\frac{1}{2}$ w
R495	302-824	820 k	$\frac{1}{2}$ w
R496	302-824	820 k	$\frac{1}{2}$ w
R497	302-474	470 k	$\frac{1}{2}$ w

†R433 and R436 furnished as a unit.

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description	S/N Range		
R506	306-683	68 k	2 w			
R510	302-105	1 meg	1/2 w			
R511	302-470	47 Ω	1/2 w			
R512	302-101	100 Ω	1/2 w			
R513	306-683	68 k	2 w			
R520	301-683	68 k	1/2 w	5%		
R521	301-105	1 meg	1/2 w	5%		
R522	302-103	10 k	1/2 w			7000-11839
R522	302-0470-00	47 Ω	1/2 w			11840-up
R523	302-474	470 k	1/2 w			
R525	302-102	1 k	1/2 w			
R526	306-332	3.3 k	2 w			
R528	302-185	1.8 meg	1/2 w			
R529	302-105	1 meg	1/2 w			
R530	301-683	68 k	1/2 w	5%		
R531	301-105	1 meg	1/2 w	5%		
R532	302-103	10 k	1/2 w			7000-11839
R532	302-0470-00	47 Ω	1/2 w			11840-up
R533	302-474	470 k	1/2 w			
R535	302-102	1 k	1/2 w			
R536	306-332	3.3 k	2 w			
R538	302-185	1.8 meg	1/2 w			
R539	302-105	1 meg	1/2 w			
R550	302-105	1 meg	1/2 w			
R551	316-101	100 Ω	1/4 w			
R555	302-473	47 k	1/2 w			
R556	302-123	12 k	1/2 w			
R561	302-101	100 Ω	1/2 w			
R564	302-103	10 k	1/2 w			
R565	302-104	100 k	1/2 w			
R566	302-473	47 k	1/2 w			
R567	302-101	100 Ω	1/2 w			
R568	304-103	10 k	1 w			
R569	302-104	100 k	1/2 w			
R571	308-008	10 k	5 w			
R572	311-015	10 k		Var	WW	5% DELAY STOP ADJ.
R573	311-022	30 k		Var	WW	TIME-BASE A DEL. TRIGGER MULT. 1-10
R576	311-141	2 k		Var	WW	DELAY START ADJ.
R577	308-024	15 k	10 w		WW	5%
R581	302-101	100 Ω	1/2 w			
R583	302-272	2.7 k	1/2 w			
R584	309-044	95 k	1/2 w		Prec	1%
R586	309-049	150 k	1/2 w		Prec	1%
R587	306-393	39 k	2 w			
R591	302-101	100 Ω	1/2 w			
R593	302-332	3.3 k	1/2 w			
R594	302-103	10 k	1/2 w			

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description	S/N Range			
R595	302-274	270 k	$\frac{1}{2}$ w				
R596	302-101	100 Ω	$\frac{1}{2}$ w				
R597	302-470	47 Ω	$\frac{1}{2}$ w				
R598	302-102	1 k	$\frac{1}{2}$ w				
R602	311-055	50 Ω		Var	WW	SCALE ILLUM.	7000-8999
	311-377	25 Ω		Var	WW	SCALE ILLUM.	9000-up
R608	302-333	33 k	$\frac{1}{2}$ w				
R610	302-104	100 k	$\frac{1}{2}$ w				
R615	310-054	68 k	1 w		Prec	1%	
R616	311-015	10 k		Var	WW	—150 V ADJ.	
R617	310-086	50 k	1 w		Prec	1%	
R618	302-104	100 k	$\frac{1}{2}$ w				
R621	302-102	1 k	$\frac{1}{2}$ w				
R623	302-474	470 k	$\frac{1}{2}$ w				
R625	302-104	100 k	$\frac{1}{2}$ w				
R628	302-335	3.3 meg	$\frac{1}{2}$ w				
R629	302-225	2.2 meg	$\frac{1}{2}$ w				
R633	302-155	1.5 meg	$\frac{1}{2}$ w				
R635	304-183	18 k	1 w				
R636	302-123	12 k	$\frac{1}{2}$ w				
R637	302-224	220 k	$\frac{1}{2}$ w				
R638	302-683	68 k	$\frac{1}{2}$ w				
R639	302-154	150 k	$\frac{1}{2}$ w				
R640	306-100	10 Ω	2 w				
R641	306-100	10 Ω	2 w				
R642	304-154	150 k	1 w				
R643	302-102	1 k	$\frac{1}{2}$ w				
R646	308-037	1 k	25 w		WW	5%	
R647	308-155	800 Ω	25 w		WW	5%	7000-9479
R647	308-037	1 k	25 w		WW	5%	9480-up
R650	310-056	333 k	1 w		Prec	1%	
R651	310-057	490 k	1 w		Prec	1%	
R663	302-155	1.5 meg	$\frac{1}{2}$ w				
R667	302-824	820 k	$\frac{1}{2}$ w				
R668	302-473	47 k	$\frac{1}{2}$ w				
R669	302-393	39 k	$\frac{1}{2}$ w				
R670	304-100	10 Ω	1 w				
R671	304-823	82 k	1 w				
R672	304-100	10 Ω	1 w				
R673	302-102	1 k	$\frac{1}{2}$ w				
R675	308-029	400 Ω	20 w		WW	5%	
R677	308-096	500 Ω	20 w		WW	5%	
R678	308-135	5 k	5 w		WW	5%	X9480-up
R679	308-135	5 k	5 w		WW	5%	X9480-up
R680	310-056	333 k	1 w		Prec	1%	
R681	310-055	220 k	1 w		Prec	1%	
R682	302-124	120 k	$\frac{1}{2}$ w				
R683	302-102	1 k	$\frac{1}{2}$ w				
R685	302-823	82 k	$\frac{1}{2}$ w				

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R686	302-184	180 k	$\frac{1}{2}$ w			
R688	302-155	1.5 meg	$\frac{1}{2}$ w			
R689	302-225	2.2 meg	$\frac{1}{2}$ w			
R693	302-155	1.5 meg	$\frac{1}{2}$ w			
R697	302-125	1.2 meg	$\frac{1}{2}$ w			
R698	302-274	270 k	$\frac{1}{2}$ w			
R699	302-563	56 k	$\frac{1}{2}$ w			
R700	306-100	10 Ω	2 w			
R701	306-100	10 Ω	2 w			
R702	304-224	220 k	1 w			
R703	302-102	1 k	$\frac{1}{2}$ w			
R704	302-102	1 k	$\frac{1}{2}$ w			
R707	308-147	750 Ω	25 w	WW	5%	7000-9479
R707	308-102	1.25 k	25 w	WW	5%	9480-up
R710	310-124	237 k	1 w	Prec	1%	
R711	Use 323-385	100 k	$\frac{1}{2}$ w	Prec	1%	
R712	302-154	150 k	$\frac{1}{2}$ w			
R717	302-104	100 k	$\frac{1}{2}$ w			
R723	302-155	1.5 meg	$\frac{1}{2}$ w			
R727	302-105	1 meg	$\frac{1}{2}$ w			
R728	302-564	560 k	$\frac{1}{2}$ w			
R729	302-473	47 k	$\frac{1}{2}$ w			
R730	306-180	18 Ω	2 w			
R731	306-180	18 Ω	2 w			
R732	304-224	220 k	1 w			
R733	306-180	18 Ω	2 w			
R734	302-102	1 k	$\frac{1}{2}$ w			
R735	302-102	1 k	$\frac{1}{2}$ w			
R736	308-037	1 k	25 w	WW	5%	7000-9479
R736	308-040	1.5 k	25 w	WW	5%	9480-up
R737	308-037	1 k	25 w	WW	5%	7000-9479
R737	308-040	1.5 k	25 w	WW	5%	9480-up
R738	308-037	1 k	25 w	WW	5%	7000-9479
R738	308-040	1.5 k	25 w	WW	5%	9480-up
R740	310-055	220 k	1 w	Prec	1%	
R741	310-059	720 k	1 w	Prec	1%	
R753	302-105	1 meg	$\frac{1}{2}$ w			
R757	302-154	150 k	$\frac{1}{2}$ w			
R758	302-124	120 k	$\frac{1}{2}$ w			
R759	302-273	27 k	$\frac{1}{2}$ w			
R760	304-100	10 Ω	1 w			
R761	304-154	150 k	1 w			
R762	304-823	82 k	1 w			
R763	302-102	1 k	$\frac{1}{2}$ w			
R767	308-055	1.5 k	10 w	WW	5%	
R775	306-221	220 Ω	2 w			
R776	302-470	47 Ω	$\frac{1}{2}$ w			
R778	302-470	47 Ω	$\frac{1}{2}$ w			
R781	302-104	100 k	$\frac{1}{2}$ w			

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R784	302-102	1 k	$\frac{1}{2}$ w			
R790	302-104	100 k	$\frac{1}{2}$ w			
R791	302-102	1 k	$\frac{1}{2}$ w			
R792	302-475	4.7 meg	$\frac{1}{2}$ w			
R793	302-474	470 k	$\frac{1}{2}$ w			
R794	309-226	9.7 k	$\frac{1}{2}$ w		Prec	1%
R795	302-565	5.6 meg	$\frac{1}{2}$ w			
R796	302-185	1.8 meg	$\frac{1}{2}$ w			
R798	304-100	10 Ω	1 w			
R799	311-001	10 Ω		Var	WW	REG. HTR. ADJ.
R803	Use 306-823	82 k	2 w			
R806	302-473	47 k	$\frac{1}{2}$ w			
R807	302-152	1.5 k	$\frac{1}{2}$ w			
R814	302-474	470 k	$\frac{1}{2}$ w			
R818	302-125	1.2 meg	$\frac{1}{2}$ w			
R819	302-225	2.2 meg	$\frac{1}{2}$ w			
R820	302-473	47 k	$\frac{1}{2}$ w			
R824	302-475	4.7 meg	$\frac{1}{2}$ w			
R825	302-475	4.7 meg	$\frac{1}{2}$ w			
R826	311-041	1 meg		Var		INTENSITY
R827	302-273	27 k	$\frac{1}{2}$ w			
R828	302-105	1 meg	$\frac{1}{2}$ w			
R844	302-103	10 k	$\frac{1}{2}$ w			
R847	302-273	27 k	$\frac{1}{2}$ w			
R848	302-105	1 meg	$\frac{1}{2}$ w			
R850	302-824	820 k	$\frac{1}{2}$ w			
R852	311-039	1 meg		Var		H.V. ADJ.
R853	302-155	1.5 meg	$\frac{1}{2}$ w			
R854	302-155	1.5 meg	$\frac{1}{2}$ w			
R856	311-043	2 meg		Var		FOCUS
R857	302-105	1 meg	$\frac{1}{2}$ w			
R861	311-026	100 k		Var		
R863	311-219	200 k	.2 w	Var		
R864	311-026	100 k		Var		
R870	302-154	150 k	$\frac{1}{2}$ w			GEOM. ADJ. 2 SHIELD VOLT. ADJ. UPPER ASTIGMATISM
R871	302-275	2.7 meg	$\frac{1}{2}$ w			
R872	302-102	1 k	$\frac{1}{2}$ w			
R874	302-395	3.9 meg	$\frac{1}{2}$ w			
R875	302-683	68 k	$\frac{1}{2}$ w			
R876	302-102	1 k	$\frac{1}{2}$ w			
R878	304-333	33 k	1 w			
R879	311-016	10 k		Var		CAL. ADJ.
R880	302-104	100 k	$\frac{1}{2}$ w			
R883	302-101	100 Ω	$\frac{1}{2}$ w			
R885	309-121	9.5 k	$\frac{1}{2}$ w		Prec	1%

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R886	309-119	6.375 k	$\frac{1}{2}$ w	Prec	1%
R887	309-117	2.1 k	$\frac{1}{2}$ w	Prec	1%
R888	309-116	1.025 k	$\frac{1}{2}$ w	Prec	1%
R889	309-113	610 Ω	$\frac{1}{2}$ w	Prec	1%
R890	309-073	200 Ω	$\frac{1}{2}$ w	Prec	1%
R891	309-112	100 Ω	$\frac{1}{2}$ w	Prec	1%
R892	309-067	60 Ω	$\frac{1}{2}$ w	Prec	1%
R893	309-066	40 Ω	$\frac{1}{2}$ w	Prec	1%
R896	309-045	100 k	$\frac{1}{2}$ w	Prec	1%
R897	309-112	100 Ω	$\frac{1}{2}$ w	Prec	1%
R898	302-101	100 Ω	$\frac{1}{2}$ w		
R899	*308-090	.25 Ω	1 w	WW	
R903	308-027	30 k	10 w	WW	5%
R906	302-473	47 k	$\frac{1}{2}$ w		
R907	302-152	1.5 k	$\frac{1}{2}$ w		
R914	302-474	470 k	$\frac{1}{2}$ w		
R918	302-185	1.8 meg	$\frac{1}{2}$ w		
R919	302-185	1.8 meg	$\frac{1}{2}$ w		
R920	316-473	47 k	$\frac{1}{4}$ w		
R924	302-475	4.7 meg	$\frac{1}{2}$ w		
R925	302-475	4.7 meg	$\frac{1}{2}$ w		
R926	311-041	1 meg		Var	INTENSITY
R927	302-333	33 k	$\frac{1}{2}$ w		
R928	302-105	1 meg	$\frac{1}{2}$ w		
R935	316-105	1 meg	$\frac{1}{4}$ w		
R944	316-103	10 k	$\frac{1}{4}$ w		
R947	302-273	27 k	$\frac{1}{2}$ w		
R948	302-105	1 meg	$\frac{1}{2}$ w		
R950	302-824	820 k	$\frac{1}{2}$ w		
R952	311-039	1 meg		Var	H.V. ADJ.
R953	302-155	1.5 meg	$\frac{1}{2}$ w		
R954	302-155	1.5 meg	$\frac{1}{2}$ w		
R956	311-043	2 meg		Var	FOCUS
R957	302-105	1 meg	$\frac{1}{2}$ w		
R961	311-026	100 k		Var	GEOM. ADJ. 1
R964	311-026	100 k		Var	
R973	311-151	20 k		Var	
R974	308-091	2 k	5 w		LOWER ASTIGMATISM
R975	308-135	5 k	5 w		CRT BEAM ROTATION
R1003	304-101	100 Ω	1 w		5%
R1005	304-101	100 Ω	1 w		
R1007	302-470	47 Ω	$\frac{1}{2}$ w		
R1008	302-470	47 Ω	$\frac{1}{2}$ w		
R1009	304-101	100 Ω	1 w		
R1011	302-270	27 Ω	$\frac{1}{2}$ w		

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R1013	305-911	910 Ω	2 w		5%
R1014	309-179	500 Ω	$\frac{1}{2}$ w	Prec	1%
R1016	308-062	3 k	5 w	WW	5%
R1017	308-126	10 k	8 w	WW	5%
R1018	302-331	330 Ω	$\frac{1}{2}$ w		
R1019	302-474	470 k	$\frac{1}{2}$ w		
R1021	302-270	27 Ω	$\frac{1}{2}$ w		
R1024	309-179	500 Ω	$\frac{1}{2}$ w	Prec	1%
R1026	302-331	330 Ω	$\frac{1}{2}$ w		
R1027	311-333	200 Ω	2 w	Var	GAIN ADJ. 7000-11429
R1027	311-0621-00	125 Ω	2 w	Var	GAIN ADJ. 11430-up
R1029	302-474	470 k	$\frac{1}{2}$ w		
R1031	304-222	2.2 k	1 w		
R1033	308-127	2.5 k	5 w	WW	5%
R1036	306-273	27 k	2 w		
R1039	302-330	33 Ω	$\frac{1}{2}$ w		
R1046	306-273	27 k	2 w		
R1049	302-330	33 Ω	$\frac{1}{2}$ w		
R1052	302-474	470 k	$\frac{1}{2}$ w		
R1054	308-104	167 Ω	5 w	WW	5%
R1055	308-066	4.5 k	5 w	WW	5%
R1062	302-474	470 k	$\frac{1}{2}$ w		
R1071 } R1073 }	*312-587	600 Ω	5 w	checked, matched $\frac{1}{2}$ % of each other	
R1075	316-221	220 Ω	$\frac{1}{4}$ w		
R1077	316-470	47 Ω	$\frac{1}{4}$ w		
R1078	316-151	150 Ω	$\frac{1}{4}$ w		
R1080	302-124	120 k	$\frac{1}{2}$ w		
R1081	302-334	330 k	$\frac{1}{2}$ w		
R1083	302-394	390 k	$\frac{1}{2}$ w		
R1084	302-684	680 k	$\frac{1}{2}$ w		
R1085	316-105	1 meg	$\frac{1}{4}$ w		
R1090	316-682	6.8 k	(nominal value)		
R1091	311-061	250 k		Var	DC SHIFT COMP.
R1092	302-473	47 k	$\frac{1}{2}$ w		
R1093	304-563	56 k	1 w		
R1094	307-006	68 k	$\frac{1}{10}$ w		
R1095	316-682	6.8 k	(nominal value)	Selected	
R1097	302-473	47 k	$\frac{1}{2}$ w		
R1099	307-006	68 k	$\frac{1}{10}$ w		
R1102	302-474	470 k	$\frac{1}{2}$ w		
R1105	308-066	4.5 k	5 w	WW	5%
R1112	302-474	470 k	$\frac{1}{2}$ w		
R1122	302-474	470 k	$\frac{1}{2}$ w		
R1125	308-066	4.5 k	5 w	WW	5%
R1132	302-474	470 k	$\frac{1}{2}$ w		

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R1142	302-474	470 k	$\frac{1}{2}$ w		
R1145	308-066	4.5 k	5 w	WW	5%
R1152	302-474	470 k	$\frac{1}{2}$ w		
R1162	302-474	470 k	$\frac{1}{2}$ w		
R1165	308-066	4.5 k	5 w	WW	5%
R1172	302-474	470 k	$\frac{1}{2}$ w		
R1182	302-474	470 k	$\frac{1}{2}$ w		
R1185	308-066	4.5 k	5 w	WW	5%
R1192	302-474	470 k	$\frac{1}{2}$ w		
R1202	302-474	470 k	$\frac{1}{2}$ w		
R1205	308-066	4.5 k	5 w	WW	5%
R1206	301-361	360 Ω	$\frac{1}{2}$ w		5%
R1208	308-069	12 k	8 w	WW	5%
R1212	302-474	470 k	$\frac{1}{2}$ w		
R1216	301-361	360 Ω	$\frac{1}{2}$ w		5%
R1218	308-106	1 k	5 w	WW	5%
R1221	302-101	100 Ω	$\frac{1}{2}$ w		
R1223	306-472	4.7 k	2 w		
R1224	308-027	30 k	10 w	WW	5%
R1227	302-394	390 k	$\frac{1}{2}$ w		
R1228	316-105	1 meg	$\frac{1}{4}$ w		
R1301	302-102	1 k	$\frac{1}{2}$ w		
R1302	302-102	1 k	$\frac{1}{2}$ w		
R1303	302-102	1 k	$\frac{1}{2}$ w		
R1304	302-102	1 k	$\frac{1}{2}$ w		
R1305	302-102	1 k	$\frac{1}{2}$ w		
R1306	302-102	1 k	$\frac{1}{2}$ w		
R1307	302-102	1 k	$\frac{1}{2}$ w		
R1308	302-102	1 k	$\frac{1}{2}$ w		
R1424	302-154	150 k	$\frac{1}{2}$ w		
R1484	302-104	100 k	$\frac{1}{2}$ w		
R2003	304-101	100 Ω	1 w		
R2005	304-101	100 Ω	1 w		
R2007	302-470	47 Ω	$\frac{1}{2}$ w		
R2008	302-470	47 Ω	$\frac{1}{2}$ w		
R2009	304-101	100 Ω	1 w		
R2011	302-270	27 Ω	$\frac{1}{2}$ w		
R2013	305-911	910 Ω	2 w		5%
R2014	309-179	500 Ω	$\frac{1}{2}$ w	Prec WW	1%
R2016	308-062	3 k	5 w		5%
R2017	308-126	10 k	8 w	WW	5%
R2018	302-331	330 Ω	$\frac{1}{2}$ w		
R2019	302-474	470 k	$\frac{1}{2}$ w		
R2021	302-270	27 Ω	$\frac{1}{2}$ w		
R2024	309-179	500 Ω	$\frac{1}{2}$ w	Prec	1%

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R2026	302-331	330 Ω	$\frac{1}{2}$ w		
R2027	311-333	200 Ω	2 w	Var	GAIN ADJ. 7000-11429
R2027	311-0621-00	125 Ω	2 w	Var	GAIN ADJ. 11430-up
R2029	302-474	470 k	$\frac{1}{2}$ w		
R2031	304-222	2.2 k	1 w		
R2033	308-127	2.5 k	5 w	WW	5%
R2036	306-273	27 k	2 w		
R2039	302-330	33 Ω	$\frac{1}{2}$ w		
R2046	306-273	27 k	2 w		
R2049	302-330	33 Ω	$\frac{1}{2}$ w		
R2052	302-474	470 k	$\frac{1}{2}$ w		
R2054	308-104	167 Ω	5 w	WW	5%
R2055	308-066	4.5 k	5 w	WW	5%
R2062	302-474	470 k	$\frac{1}{2}$ w		
R2071 } R2073 }	*312-587	600 Ω	5 w	Checked, matched $\frac{1}{2}$ % of each other	
R2075	316-221	220 Ω	$\frac{1}{4}$ w		
R2077	316-470	47 Ω	$\frac{1}{4}$ w		
R2078	316-151	150 Ω	$\frac{1}{4}$ w		
R2080	302-124	120 k	$\frac{1}{2}$ w		
R2081	302-334	330 k	$\frac{1}{2}$ w		
R2083	302-394	390 k	$\frac{1}{2}$ w		
R2084	302-684	680 k	$\frac{1}{2}$ w		
R2085	316-105	1 meg	$\frac{1}{4}$ w		
R2090	316-682	6.8 k	(nominal value)	Selected	
R2091	311-061	250 k		Var	DC SHIFT COMP.
R2092	302-473	47 k	$\frac{1}{2}$ w		
R2093	304-563	56 k	1 w		
R2094	307-006	68 k	$\frac{1}{10}$ w		
R2095	316-682	6.8 k	(nominal value)	Selected	
R2097	302-473	47 k	$\frac{1}{2}$ w		
R2099	307-006	68 k	$\frac{1}{10}$ w		
R2102	302-474	470 k	$\frac{1}{2}$ w		
R2105	308-066	4.5 k	5 w	WW	5%
R2112	302-474	470 k	$\frac{1}{2}$ w		
R2122	302-474	470 k	$\frac{1}{2}$ w		
R2125	308-066	4.5 k	5 w	WW	5%
R2132	302-474	470 k	$\frac{1}{2}$ w		
R2142	302-474	470 k	$\frac{1}{2}$ w		
R2145	308-066	4.5 k	5 w	WW	5%
R2152	302-474	470 k	$\frac{1}{2}$ w		
R2162	302-474	470 k	$\frac{1}{2}$ w		
R2165	308-066	4.5 k	5 w	WW	5%
R2172	302-474	470 k	$\frac{1}{2}$ w		
R2182	302-474	470 k	$\frac{1}{2}$ w		
R2185	308-066	4.5 k	5 w	WW	5%

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R2192	302-474	470 k	$\frac{1}{2}$ w		
R2202	302-474	470 k	$\frac{1}{2}$ w		
R2205	308-066	4.5 k	5 w	WW	5%
R2206	301-361	360 Ω	$\frac{1}{2}$ w		5%
R2208	308-069	12 k	8 w	WW	5%
R2212	302-474	470 k	$\frac{1}{2}$ w		
R2216	301-361	360 Ω	$\frac{1}{2}$ w		5%
R2218	308-106	1 k	5 w	WW	5%
R2221	302-101	100 Ω	$\frac{1}{2}$ w		
R2223	306-472	4.7 k	2 w		
R2224	308-027	30 k	10 w	WW	5%
R2227	302-394	390 k	$\frac{1}{2}$ w		
R2228	316-105	1 meg	$\frac{1}{4}$ w		
R2301	302-102	1 k	$\frac{1}{2}$ w		
R2302	302-102	1 k	$\frac{1}{2}$ w		
R2303	302-102	1 k	$\frac{1}{2}$ w		
R2304	302-102	1 k	$\frac{1}{2}$ w		
R2305	302-102	1 k	$\frac{1}{2}$ w		
R2306	302-102	1 k	$\frac{1}{2}$ w		
R2307	302-102	1 k	$\frac{1}{2}$ w		
R2308	302-102	1 k	$\frac{1}{2}$ w		
R2423	302-104	100 k	$\frac{1}{2}$ w		
R2424	302-154	150 k	$\frac{1}{2}$ w		

Switches

	Unwired	Wired		
SW332	260-270	*262-613	Rotary	HORIZONTAL DISPLAY (Upper Beam) Rear
SW350	260-269	*262-213	Rotary	HORIZONTAL DISPLAY (Upper Beam) Front
SW432	260-270	*262-614	Rotary	HORIZONTAL DISPLAY (Lower Beam) Rear
SW450	260-269	*262-214	Rotary	HORIZONTAL DISPLAY (Lower Beam) Front
SW601	260-276		Toggle	POWER ON
SW848	260-209		Toggle	CRT CATHODE SELECTOR (Upper Beam)
SW870	260-253	*262-212	Rotary	AMPLITUDE CALIBRATOR
SW948	260-209		Toggle	CRT CATHODE SELECTOR (Lower Beam)

Transformers

T601	Use	*120-0128-01	Power, Plate	7000-9479
T601		*120-351	Power, Plate	9480-up
T602	Use	*120-0127-01	Power, Filament	7000-9479
T602		*120-350	Power, Filament	9480-up
T750	Use	*120-0122-01	Indicator, Filament	
T801		*120-123	H.V. Upper Beam	
T901		*120-124	H.V. Lower Beam and Post Accelerator	

Thermal Cutouts

Ckt. No.	Tektronix Part No.	Description	S/N Range
TK601	260-208	Thermal Cutout, 133° F	
TK750	260-208	Thermal Cutout, 133° F	

Electron Tubes

V314	154-187	6DJ8/ECC88	
V343	154-187	6DJ8/ECC88	
V364	154-187	6DJ8/ECC88	
V384	154-187	6DJ8/ECC88	
V398	154-031	6CL6	
V414	154-187	6DJ8/ECC88	
V443	154-187	6DJ8/ECC88	
V464	154-187	6DJ8/ECC88	
V484	154-187	6DJ8/ECC88	
V498	154-031	6CL6	
V513	154-022	6AU6	
V524	154-187	6DJ8/ECC88	
V534	154-187	6DJ8/ECC88	
V554	154-022	6AU6	
V564	154-022	6AU6	
V568	154-187	6DJ8/ECC88	
V585	154-187	6DJ8/ECC88	
V609	154-052	5651	
V624	154-043	12AX7	
V634	154-022	6AU6	
V647	154-056	6080	
V664	154-022	6AU6	
V677	154-056	6080	
V684	154-043	12AX7	
V694	154-022	6AU6	
V707	154-056	6080	
V724	154-022	6AU6	
V727	154-056	6080	
V737	154-056	6080	
V754	154-022	6AU6	
V757	154-044	12B4	
V767	154-044	12B4	
V794	154-167	6CZ5	
V799	154-006	2AS-15	
V800	154-167	6CZ5	
V814	154-041	12AU7	
V859	*154-199	T5550-2 CRT Standard Phosphor	7000-8999
V859†	Use *154-0476-00	T5550-2-1 CRT Standard Phosphor	9000-10409
V859	*154-0476-00	T5550-2-1 CRT Standard Phosphor	10410-11549
V859	*154-0476-03	T5550-31-1 CRT Standard Phosphor	11550-up
V862	154-051	5642	
V875	154-022	6AU6	
V822	154-051	5642	

† S/N 9000-10409 add *050-0246-00 kit.

Electron Tubes (Cont'd)

Ckt. No.	Tektronix Part No.	Description		S/N Range
V885	154-041	12AU7		
V900	154-167	6CZ5		
V914	154-041	12AU7		
V922	154-051	5642		
V932	154-051	5642		
V942	154-051	5642		
V962	154-051	5642		
V1014	*157-053†	12BY7	Selected	
V1024				
V1033		6DJ8/ECC88		
V1043	154-187	6DJ8/ECC88		
V1054	154-367	8136/6DK6		
V1064	154-367	8136/6DK6		
V1084	154-187	6DJ8/ECC88		
V1104	154-367	8136/6DK6		
V1114	154-367	8136/6DK6		
V1124	154-367	8136/6DK6		
V1134	154-367	8136/6DK6		
V1144	154-367	8136/6DK6		
V1154	154-367	8136/6DK6		
V1164	154-367	8136/6DK6		
V1174	154-367	8136/6DK6		
V1184	154-367	8136/6DK6		
V1194	154-367	8136/6DK6		
V1204	154-367	8136/6DK6		
V1214	154-367	8136/6DK6		
V1223	154-187	6DJ8/ECC88		
V2014	*157-053†	12BY7	Selected	
V2024				
V2033		6DJ8/ECC88		
V2043	154-187	6DJ8/ECC88		
V2054	154-367	8136/6DK6		
V2064	154-367	8136/6DK6		
V2104	154-367	8136/6DK6		
V2114	154-367	8136/6DK6		
V2124	154-367	8136/6DK6		
V2134	154-367	8136/6DK6		
V2144	154-367	8136/6DK6		
V2154	154-367	8136/6DK6		
V2164	154-367	8136/6DK6		

†V1014 and V1024 furnished as a unit.

††V2014 and V2024 furnished as a unit.

Electron Tubes (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
V2174	154-367	8136/6DK6	
V2184	154-367	8136/6DK6	
V2194	154-367	8136/6DK6	
V2204	154-367	8136/6DK6	
V2214	154-367	8136/6DK6	
V2223	154-187	6DJ8/ECC88	

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description			S/N Range
Bulbs					
B129	260-518	Part of SW101		READY	
B160W	Use 150-027	Neon, NE-23		UNCALIBRATED	7000-11409
B160W	150-0030-00	Neon, NE-2V		UNCALIBRATED	11410-up
B167	Use 150-027	Neon, NE-23			
B170	Use 150-027	Neon, NE-23			
Capacitors					
Tolerance $\pm 20\%$ unless otherwise indicated.					
Tolerance of all electrolytic capacitors as follows (with exceptions):					
3 V — 50 V = -10% , $+250\%$					
51 V — 350 V = -10% , $+100\%$					
351 V — 450 V = -10% , $+ 50\%$					
C1	281-593	3.9 pf	Cer	500 v	10%
C5	283-026	.2 μ f	Disc Type	25 v	
C6	281-593	3.9 pf	Cer	500 v	10%
C10	283-000	.001 μ f	Disc Type	500 v	
C15	283-000	.001 μ f	Disc Type	500 v	
C20	283-003	.01 μ f	Disc Type	150 v	
C30	283-0113-00	56 pf	Disc Type	500 v	X11000-up
C37	283-002	.01 μ f	Disc Type	500 v	
C38	283-076	27 pf	Disc Type	500 v	
C40	283-076	27 pf	Disc Type	500 v	
C48	283-003	.01 μ f	Disc Type	150 v	
C101	283-001	.005 μ f	Disc Type	500 v	7000-10999X
C102	281-525	470 pf	Cer	500 v	7000-10999X
C105	290-121	2 μ f	EMT	25 v	
C108	285-572	.1 μ f	PTM	200 v	
C112	283-001	.005 μ f	Disc Type	500 v	
C119	283-001	.005 μ f	Disc Type	500 v	
C123	281-504	10 pf	Cer	500 v	10%
C129	283-001	.005 μ f	Disc Type	500 v	
C131	281-549	68 pf	Cer	500 v	10%
C134	281-501	47 pf	Cer	500 v	± 1 pf
C138	283-002	.01 μ f	Disc Type	500 v	
C141	281-503	8 pf	Cer	500 v	± 0.5 pf
C150	281-528	82 pf	Cer	500 v	10%
C160A	281-007	3-12 pf	Cer	Var	
C160B	283-534	82 pf	Mica	500 v	5%
C160C	281-010	4.5-25 pf	Cer	Var	
C160D	283-534	82 pf	Mica	500 v	5%
C160E	281-010	4.5-25 pf	Cer	Var	
C160F	*291-008	.001 μ f			$\frac{1}{2}\%$

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.	Description			S/N Range
C160G } C160H } C160J }	*291-007	.01 μ f } .1 μ f } 1 μ f }	Timing Series		1/2 %
C165	281-528	82 pf	Cer	500 v	10%
C167	283-000	.001 μ f	Disc Type	500 v	
C174	281-513	27 pf	Cer	500 v	
C180A	283-536	220 pf	Mica	500 v	10%
C180B	285-543	.0022 μ f	MT	400 v	
C180C	285-515	.022 μ f	MT	400 v	
C180D	285-526	.1 μ f	MT	400 v	
C180E	285-526	.1 μ f	MT	400 v	
C181	281-517	39 pf	Cer	500 v	10%
C186	283-000	.001 μ f	Disc Type	500 v	
C191	281-550	120 pf	Cer	500 v	10%
C193	283-006	.02 μ f	Disc Type	600 v	
C195	281-509	15 pf	Cer	500 v	10%
C198	283-001	.005 μ f	Disc Type	500 v	

Diodes

D24	152-141	Silicon	1N3605	7000-10999
D24	*152-0185-00	Silicon	Replaceable by 1N3605	11000-up
D25	152-141	Silicon	1N3605	7000-10999
D25	*152-0185-00	Silicon	Replaceable by 1N3605	11000-up
D38	*152-125	Tunnel	Selected TD3A 4.7 MA	7000-10999
D38	152-0154-00	Tunnel	TD253 10 MA	11000-up
D40	Use 152-081	Tunnel	TD2 2.2 MA	7000-10999
D40	*152-0185-00	Silicon	Replaceable by 1N3605	11000-up
D42	*152-0185-00	Silicon	Replaceable by 1N3605	X11000-up
D45	*152-125	Tunnel	Selected TD3A 4.7 MA	
D108	*152-061	Silicon	Tek Spec	7000-10999
D108	*152-0185-00	Silicon	Replaceable by 1N3605	11000-up
D132	152-008	Germanium		
D134	*152-061	Silicon	Tek Spec	
D152	152-0246-00	Silicon	Low leakage 0.25 w, 40 v	X11640-up

Inductors

L24	276-507	Core, Ferramic Suppressor		
L25	276-507	Core, Ferramic Suppressor		
L40	*108-0103-00	2.5 μ h		X11000-up
T40	*120-329	Toroid 15T Bilfilar		7000-10999X
L42	Use *120-337	Toroid single winding		
LR149	*108-173	1.59 mh		

		Resistors				
Ckt. No.	Tektronix Part No.	Description			S/N Range	
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.						
R1	301-105	1 meg	$\frac{1}{2}$ w	Var	5%	TRIG. DC LEVEL (Lower Beam)
R2	301-434	430 k	$\frac{1}{2}$ w		5%	
R3	311-110	100 k				
R5	316-103	10 k	$\frac{1}{4}$ w	Var		TRIG. DC LEVEL (Upper Beam)
R6	301-105	1 meg	$\frac{1}{4}$ w		5%	
R7	301-434	430 k	$\frac{1}{2}$ w		5%	
R8	311-110	100 k				
R12	302-105	1 meg	$\frac{1}{2}$ w	Var		TRIGGER LEVEL VERNIER
R15	316-474	470 k	$\frac{1}{4}$ w			
R16	316-474	470 k	$\frac{1}{4}$ w			
R17 } R21 }	311-414	2 x 100 k				
R18	316-563	56 k	$\frac{1}{4}$ w			
R19	302-475	4.7 meg	$\frac{1}{2}$ w	Var		7000-10999 11000-up
R19	316-0475-00	4.7 meg	$\frac{1}{4}$ w			
R20	316-185	1.8 meg	$\frac{1}{4}$ w			
R22	316-470	47 Ω	$\frac{1}{4}$ w			
R23	316-470	47 Ω	$\frac{1}{4}$ w			
R24	316-0470-00	47 Ω	$\frac{1}{4}$ w	Var		X11000-up X11000-up TRIG. LEVEL CENT. 5% 7000-10999 5% 11000-up
R25	311-0433-00	100 Ω				
R26	311-328	1 k				
R28	308-108	15 k	5 w		WW	
R28	308-0262-00	15 k	5 w		WW	
R30	308-212	10 k	3 w	WW	5%	7000-10999 11000-up X11000-up 7000-10999 11000-up
R30	308-0310-00	12 k	5 w		1%	
R31	308-0310-00	12 k	5 w		1%	
R32	316-471	470 Ω	$\frac{1}{4}$ w			
R32	315-0471-00	470 Ω	$\frac{1}{4}$ w		5%	
R33	316-471	470 Ω	$\frac{1}{4}$ w	WW		7000-10999 11000-up 7000-10999 11000-up 7000-10999
R33	315-0471-00	470 Ω	$\frac{1}{4}$ w		5%	
R34	316-471	470 Ω	$\frac{1}{4}$ w			
R34	315-0471-00	470 Ω	$\frac{1}{4}$ w		5%	
R35	316-471	470 Ω	$\frac{1}{4}$ w			
R35	315-0471-00	470 Ω	$\frac{1}{4}$ w	WW	5%	11000-up 7000-10999 11000-up 7000-10999
R36	317-101	100 Ω	$\frac{1}{10}$ w		5%	
R36	316-0105-00	1 meg	$\frac{1}{4}$ w			
R37	302-101	100 Ω	$\frac{1}{2}$ w			
R38	304-333	33 k	1 w			
R38	305-0183-00	18 k	2 w	WW	5%	11000-up X11000-up 7000-10999X 7000-10999X 7000-10999
R39	308-0310-00	12 k	5 w		1%	
R40	317-101	100 Ω	$\frac{1}{10}$ w		5%	
R41	302-273	27 k	$\frac{1}{2}$ w			
R42	316-470	47 Ω	$\frac{1}{4}$ w			

Parts List—Type 21A

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R42	315-0560-00	56Ω	1/4 w	5%	11000-up
R43	304-223	22 k	1 w		7000-10999
R43	303-0183-00	18 k	1 w	5%	11000-up
R44	311-110	100 k	Var	TD BIAS	7000-10999
R44	311-0326-00	10 k	Var	TD BIAS	11000-up
R45	316-101	100 Ω	1/4 w		
R47	304-273	27 k	1 w		
R48	302-154	150 k	1/2 w		
R49	316-562	5.6 k	1/4 w	5%	7000-10999
R49	315-0562-00	5.6 k	1/4 w		11000-up
R98	316-0101-00	100 Ω	1/4 w		X11000-up
R100	Use 302-393	39 k	1/2 w		
R101	302-475	4.7 meg	1/2 w		7000-70999
R101	302-0334-00	330 k	1/2 w		11000-up
R102	302-222	2.2 k	1/2 w		7000-10999X
R103	302-105	1 meg	1/2 w		
R104	302-103	10 k	1/2 w		
R105	302-103	10 k	1/2 w		
R106	302-153	15 k	1/2 w		
R107	302-825	8.2 meg	1/2 w		
R108	316-470	47 Ω	1/4 w		
R109	302-334	330 k	1/2 w		
R110	302-183	18 k	1/2 w		
R111	311-026	100 k		Var	STABILITY
R112	302-104	100 k	1/2 w		
R113	304-473	47 k	1 w		
R114	302-474	470 k	1/2 w		
R115	302-274	270 k	1/2 w		
R116	301-184	180 k	1/2 w	5%	
R119	302-470	47 Ω	1/2 w		
R121	302-472	4.7 k	1/2 w		
R122	302-183	18 k	1/2 w		
R123	302-274	270 k	1/2 w		
R124	302-474	470 k	1/2 w		
R125	311-329	50 k	Var		LOCKOUT LEVEL ADJ.
R126	Use 302-473	47 k	1/2 w		
R127	302-470	47 Ω	1/2 w		
R128	302-123	12 k	1/2 w		
R129	302-103	10 k	1/2 w		
R130	306-223	22 k	2 w		
R131	302-102	1 k	1/2 w		
R132	302-470	47 Ω	1/2 w		
R134	*310-555	6 k/3 k	3 w	WW	
R137	302-470	47 Ω	1/2 w		
R138	302-101	100 Ω	1/2 w		

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R139	302-104	100 k	$\frac{1}{2}$ w			
R140	308-206	7.5 k	5 w		WW	5%
R141	310-070	33 k	1 w		Prec	1%
R143	310-072	30 k	1 w		Prec	1%
R144	308-053	8 k	5 w		WW	5%
R146	302-470	47 Ω	$\frac{1}{2}$ w			
R147	302-102	1 k	$\frac{1}{2}$ w			
R148	302-393	39 k	$\frac{1}{2}$ w			
R150	302-271	270 Ω	$\frac{1}{2}$ w			
R152	316-0106-00	10 meg	$\frac{1}{4}$ w			
R160A	309-045	100 k	$\frac{1}{2}$ w		Prec	1% X11730-up
R160B	309-051	200 k	$\frac{1}{2}$ w		Prec	1%
R160C	309-003	500 k	$\frac{1}{2}$ w		Prec	1%
R160D	309-359	1 meg	$\frac{1}{2}$ w		Prec	$\frac{1}{4}$ %
R160E	309-023	2 meg	$\frac{1}{2}$ w		Prec	1%
R160F	309-087	5 meg	$\frac{1}{2}$ w		Prec	1%
R160G	310-107	10 meg	$\frac{1}{2}$ w		Prec	1%
R160H	310-107	10 meg	$\frac{1}{2}$ w		Prec	1%
R160J	310-505	30 meg	2 w		Prec	1%
R160W	302-104	100 k	$\frac{1}{2}$ w			
R160X	302-103	10 k	$\frac{1}{2}$ w			
R160Y†	311-108	20 k		Var	WW	VARIABLE
R162	304-682	6.8 k	1 w			
R163	304-123	12 k	1 w			
R164	306-223	22 k	2 w			
R165	306-223	22 k	2 w			
R166	306-223	22 k	2 w			
R167	302-155	1.5 meg	$\frac{1}{2}$ w			
R168	302-473	47 k	$\frac{1}{2}$ w			
R170	302-470	47 Ω	$\frac{1}{2}$ w			
R172	302-470	47 Ω	$\frac{1}{2}$ w			
R174	308-053	8 k	5 w		WW	5%
R175	302-470	47 Ω	$\frac{1}{2}$ w			
R176	311-008	2 k		Var		
R178	308-092	4.5 k	5 w		WW	SWP. LENGTH
R180A	302-474	470 k	$\frac{1}{2}$ w			5%
R180B	302-475	4.7 meg	$\frac{1}{2}$ w			
R181	302-475	4.7 meg	$\frac{1}{2}$ w			
R183	302-470	47 Ω	$\frac{1}{2}$ w			
R186	302-104	100 k	$\frac{1}{2}$ w			
R188	304-104	100 k	1 w			
R190	302-225	2.2 meg	$\frac{1}{2}$ w			
R191	302-104	100 k	$\frac{1}{2}$ w			
R192	302-470	47 Ω	$\frac{1}{2}$ w			
R193	302-101	100 Ω	$\frac{1}{2}$ w			
R194	306-683	68 k	2 w			

†Concentric with SW160Y. Furnished as a unit.

Parts List—Type 21A

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R195	302-473	47 k	5%
R196	301-114	110 k	
R197	302-470	47 Ω	
R198	302-470	47 Ω	
R199	304-472	4.7 k	

Switches

	Unwired	Wired			
SW8	260-558	*262-578	Rotary	SOURCE	7000-10999
SW10	260-145		Slide	COUPLING	
SW10	260-0449-00		Slide	COUPLING	11000-up
SW22	260-212		Slide	SLOPE	7000-10999
SW22	260-0447-00		Slide	SLOPE	11000-up
SW101	260-518		Push w/Neon Bulb	RESET	7000-10999
SW128	260-557	*262-574	Rotary	SWEEP FUNCTION	
SW128	260-0557-00	*262-0574-01	Rotary	SWEEP FUNCTION	
SW160	260-275	*262-575	Rotary	TIME/CM	
SW160Y†	311-108				11000-up

Transistors

Q24	151-120	2N2475	7000-7499
Q34	151-120	2N2475	
Q44	*151-108	Tek Spec.	
Q104	151-055	2N398A	
	151-071	2N1305	

Electron Tubes

V24	154-187	6DJ8	
V115	154-187	6DJ8	
V125	154-022	6AU6	
V133	154-187	6DJ8	
V135	154-187	6DJ8	
V145	154-047	12BY7	checked
V152	*157-075	12AL5	
V152	154-0038-00	12AL5	
V161	154-0040-00	12AU6	
V161	154-0040-05	8426	
V173	154-187	6DJ8	7000-11639
V183	154-187	6DJ8	
V193	154-187	6DJ8	

†Concentric with R160Y. Furnished as a unit.

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range
Bulbs			
B129	260-518	Part of SW101	READY
B160W	Use 150-027	Neon, NE-23	UNCALIBRATED
B160W	150-0030-00	Neon, NE-2V	UNCALIBRATED
B167	Use 150-027	Neon, NE-23	7000-11409
B170	Use 150-027	Neon, NE-23	11410-up
Capacitors			
Tolerance $\pm 20\%$ unless otherwise indicated.			
Tolerance of all electrolytic capacitors as follows (with exceptions):			
3 V — 50 V = -10% , $+250\%$			
51 V — 350 V = -10% , $+100\%$			
351 V — 450 V = -10% , $+ 50\%$			
C1	281-593	3.9 pf Cer	500 v 10%
C5	283-026	.2 μ f Disc Type	25 v
C6	281-593	3.9 pf Cer	500 v 10%
C10	283-000	.001 μ f Disc Type	500 v
C15	283-000	.001 μ f Disc Type	500 v
C20	283-003	.01 μ f Disc Type	150 v
C30	283-0113-00	56 pF Disc Type	500 v
C37	283-002	.01 μ f Disc Type	500 v
C38	283-076	27 pf Disc Type	500 v
C40	283-076	27 pf Disc Type	500 v
C48	283-003	.01 μ f Disc Type	150 v
C101	283-000	.001 μ f Disc Type	500 v
C102	281-511	22 pf Cer	500 v 10%
C106	283-000	.001 μ f Disc Type	500 v
C109	283-001	.005 μ f Disc Type	500 v
C110	290-121	2 μ f EMT	25 v
C112	285-572	.1 μ f PTM	200 v
C117	283-001	.005 μ f Disc Type	500 v
C119	283-001	.005 μ f Disc Type	500 v
C123	281-504	10 pf Cer	500 v 10%
C129	283-001	.005 μ f Disc Type	500 v
C131	281-549	68 pf Cer	500 v 10%
C134	281-501	4.7 pf Cer	500 v ± 1 pf
C138	283-002	.01 μ f Disc Type	500 v
C141	281-503	8 pf Cer	500 v ± 0.5 pf
C150	281-528	82 pf Cer	500 v 10%
C160A	281-007	3-12 pf Cer	Var
C160B	283-534	82 pf Mica	500 v 5%
C160B	281-010	4.5-25 pf Cer	Var
C160D	283-534	82 pf Mica	500 v 5%
C160E	281-010	4.5-25 pf Cer	Var

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.	Description		S/N Range
C160F	*291-008	.001 μ f	Timing Series	1/2 %
C160G	*291-007	.01 μ f		1/2 %
C160H		.1 μ f		
C160J		1 μ f		
C165	281-528	82 pf	Cer	500 v 10 %
C167	283-000	.001 μ f	Disc Type	500 v
C174	281-513	27 pf	Cer	500 v
C180A	283-536	220 pf	Mica	500 v 10 %
C180B	285-543	.0022 μ f	MT	400 v
C180C	285-515	.022 μ f	MT	400 v
C180D	285-526	.1 μ f	MT	400 v
C180E	285-526	.1 μ f	MT	400 v
C181	281-517	39 pf	Cer	500 v 10 %
C186	283-000	.001 μ f	Disc Type	500 v
C191	281-550	120 pf	Cer	500 v 10 %
C193	283-006	.02 μ f	Disc Type	600 v
C195	281-509	15 pf	Cer	500 v 10 %
C198	283-001	.005 μ f	Disc Type	500 v

Diodes

D24	152-141	Silicon	1N3605	7000-10999X
D24	*152-0185-00	Silicon	Replaceable by 1N3605	11000-up
D25	152-141	Silicon	1N3605	7000-10999
D25	*152-0185-00	Silicon	Replaceable by 1N3605	11000-up
D38	*152-125	Tunnel	Selected TD3A 4.7 MA	7000-10999
D38	152-0154-00	Tunnel	TD253 10 MA	11000-up
D40	Use 152-081	Tunnel	TD2	7000-10999
D40	*152-0185-00	Silicon	Replaceable by 1N3605	11000-up
D42	*152-0185-00	Silicon	Replaceable by 1N3605	X11000-up
D45	*152-125	Tunnel	Selected TD3A 4.7 MA	
D122	152-008	Germanium		
D132	152-008	Germanium		
D134	152-061	Silicon	Tek Spec	
D135	152-061	Silicon	Tek Spec	7000-10999
D135	*152-0185-00	Silicon	Replaceable by 1N3605	11000-up
D152	152-0246-00	Silicon	Low leakage 0.25 w, 40 v	X11640-up

Inductors

L24	276-507	Core, Ferramic Suppressor		
L25	276-507	Core, Ferramic Suppressor		
L40	*108-0103-00	2.5 μ h		X11000-up
T40	*120-329	Toroid 15T Bifilar		7000-10999X
L42	Use *120-337	Toroid single winding		
LR149	*108-173	1.59 mh		

Resistors

Ckt. No.	Tektronix Part No.	Description			S/N Range		
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.							
R1	301-105	1 meg	$\frac{1}{2}$ w	Var	5%	TRIG. DC LEVEL (Lower Beam)	
R2	301-434	430 k	$\frac{1}{2}$ w		5%		
R3	311-110	100 k					
R5	316-103	10 k	$\frac{1}{4}$ w	Var	5%	TRIG. DC LEVEL (Upper Beam)	
R6	301-105	1 meg	$\frac{1}{2}$ w				
R7	301-434	430 k	$\frac{1}{2}$ w				
R8	311-110	100 k					
R12	302-105	1 meg	$\frac{1}{2}$ w				
R15	316-474	470 k	$\frac{1}{4}$ w				
R16	316-474	470 k	$\frac{1}{4}$ w				
R17 } R21 }	311-414	2 x 100 k		Var		TRIGGER LEVEL VERNIER	
R18	316-563	56 k	$\frac{1}{4}$ w				
R19	302-475	4.7 meg	$\frac{1}{2}$ w				
R19	316-0475-00	4.7 meg	$\frac{1}{4}$ w			7000-10999	
R20	316-185	1.8 meg	$\frac{1}{4}$ w			11000-up	
R22	316-470	47 Ω	$\frac{1}{4}$ w	Var		X11000-up	
R23	316-470	47 Ω	$\frac{1}{4}$ w				
R24	316-0470-00	47 Ω	$\frac{1}{4}$ w				
R25	311-0433-00	100 Ω		Var		X11000-up	
R26	311-328	1 k		Var		TRIG. LEVEL CENT.	
R28	308-108	15 k	5 w		WW	5%	7000-10999
R28	308-0262-00	15 k	5 w		WW	5%	11000-up
R30	308-212	10 k	3 w		WW	5%	7000-10999
R30	308-0310-00	12 k	5 w		WW	1%	11000-up
R31	308-0310-00	12 k	5 w		WW	1%	X11000-up
R32	316-471	470 Ω	$\frac{1}{4}$ w			5%	7000-10999
R32	315-0471-00	470 Ω	$\frac{1}{4}$ w				11000-up
R33	316-471	470 Ω	$\frac{1}{4}$ w				7000-10999
R33	315-0471-00	470 Ω	$\frac{1}{4}$ w			5%	11000-up
R34	316-471	470 Ω	$\frac{1}{4}$ w			5%	7000-10999
R34	315-0471-00	470 Ω	$\frac{1}{4}$ w				11000-up
R35	316-471	470 Ω	$\frac{1}{4}$ w				7000-10999
R35	315-0471-00	470 Ω	$\frac{1}{4}$ w			5%	11000-up
R36	317-101	100 Ω	1/10 w			5%	7000-10999
R36	316-0105-00	1 meg	$\frac{1}{4}$ w				11000-up
R37	302-101	100 Ω	$\frac{1}{2}$ w			5%	7000-10999
R38	304-333	33 k	1 w				11000-up
R38	305-0183-00	18 k	2 w				
R39	308-0310-00	12 k	5 w		WW	1%	X11000-up
R40	317-101	100 Ω	1/10 w			5%	7000-10999X
R41	302-273	27 k	$\frac{1}{2}$ w				7000-10999X
R42	316-470	47 Ω	$\frac{1}{4}$ w			5%	7000-10999
R42	315-0560-00	56 Ω	$\frac{1}{4}$ w				11000-up

Parts List—Type 22A

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R43	304-223	22 k	1 w			7000-10999
R43	303-0183-00	18 k	1 w			11000-up
R44	311-110	100 k		Var	5% TD BIAS	7000-10999
R44	311-0326-00	10 k		Var		11000-up
R45	316-101	100 Ω	1/4 w			
R47	304-273	27 k	1 w			
R48	302-154	150 k	1/2 w			
R49	316-562	5.6 k	1/4 w			7000-10999
R49	315-0562-00	5.6 k	1/4 w		5%	11000-up
R98	316-101	100 Ω	1/4 w			
R99	316-680	68 Ω	1/4 w			7000-10999X
R100	Use 302-393	39 k	1/2 w			
R101	302-226	22 meg	1/2 w			7000-10999
R101	302-0334-00	330 k	1/2 w			11000-up
R102	302-223	22 k	1/2 w			7000-10999X
R103	302-102	1 k	1/2 w			7000-10999X
R104	302-105	1 meg	1/2 w			
R105	302-394	390 k	1/2 w			
R106	302-105	1 meg	1/2 w			
R107	302-470	47 Ω	1/2 w			
R108	302-103	10 k	1/2 w			
R109	302-224	220 k	1/2 w			
R110	302-103	10 k	1/2 w			
R111	311-026	100 k		Var	STABILITY	
R112	302-153	15 k	1/2 w			
R113	302-334	330 k	1/2 w			
R114	302-474	470 k	1/2 w			
R115	302-274	270 k	1/2 w			
R116	301-184	180 k	1/2 w		5%	
R117	302-183	18 k	1/2 w			
R118	302-684	680 k	1/2 w			
R119	302-470	47 Ω	1/2 w			
R120	302-104	100 k	1/2 w			
R122	304-683	68 k	1 w			
R123	302-274	270 k	1/2 w			
R124	302-474	470 k	1/2 w			
R125	311-329	50 k		Var	LOCKOUT LEVEL	
R126	Use 302-473	47 k	1/2 w			
R127	302-470	47 Ω	1/2 w			
R128	302-123	12 k	1/2 w			
R129	302-103	10 k	1/2 w			
R130	306-223	22 k	2 w			
R131	302-102	1 k	1/2 w			
R132	302-470	47 Ω	1/2 w			
R133	304-473	47 k	1 w			
R134	*310-555	6 k/3 k	3 w		WW	
R135	316-470	47 Ω	1/4 w			
R136	302-825	8.2 meg	1/2 w			
R137	302-470	47 Ω	1/2 w			

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R138	302-101	100 Ω	$\frac{1}{2}$ w			
R139	302-104	100 k	$\frac{1}{2}$ w			
R140	308-206	7.5 k	5 w		WW	5%
R141	310-070	33 k	1 w		Prec	1%
R143	310-072	30 k	1 w		Prec	1%
R144	308-053	8 k	5 w		WW	5%
R146	302-470	47 Ω	$\frac{1}{2}$ w			
R147	302-102	1 k	$\frac{1}{2}$ w			
R148	302-393	39 k	$\frac{1}{2}$ w			
R150	302-271	270 Ω	$\frac{1}{2}$ w			
R152	316-0106-00	10 meg	$\frac{1}{4}$ w			X11730-up
R160A	309-045	100 k	$\frac{1}{2}$ w		Prec	1%
R160B	309-051	200 k	$\frac{1}{2}$ w		Prec	1%
R160C	309-003	500 k	$\frac{1}{2}$ w		Prec	1%
R160D	309-359	1 meg	$\frac{1}{2}$ w		Prec	$\frac{1}{4}$ %
R160E	309-023	2 meg	$\frac{1}{2}$ w		Prec	1%
R160F	309-087	5 meg	$\frac{1}{2}$ w		Prec	1%
R160G	310-107	10 meg	1 w		Prec	1%
R160H	310-107	10 meg	1 w		Prec	1%
R160J	310-505	30 meg	2 w		Prec	1%
R160W	302-104	100 k	$\frac{1}{2}$ w			
R160X	302-103	10 k	$\frac{1}{2}$ w			
R160Y†	311-108	20 k		Var	WW	VARIABLE
R162	304-682	6.8 k	1 w			
R163	304-123	12 k	1 w			
R164	306-223	22 k	2 w			
R165	306-223	22 k	2 w			
R166	306-223	22 k	2 w			
R167	302-155	1.5 meg	$\frac{1}{2}$ w			
R168	302-473	47 k	$\frac{1}{2}$ w			
R170	302-470	47 Ω	$\frac{1}{2}$ w			
R172	302-470	47 Ω	$\frac{1}{2}$ w			
R174	308-053	8 k	5 w		WW	5%
R175	302-470	47 Ω	$\frac{1}{2}$ w			
R176	311-008	2 k		Var		SWP. LENGTH
R178	308-092	4.5 k	5 w		WW	5%
R180A	302-474	470 k	$\frac{1}{2}$ w			
R180B	302-475	4.7 meg	$\frac{1}{2}$ w			
R181	302-475	4.7 meg	$\frac{1}{2}$ w			
R183	302-470	47 Ω	$\frac{1}{2}$ w			
R186	302-104	100 k	$\frac{1}{2}$ w			
R188	304-104	100 k	1 w			
R190	302-225	2.2 meg	$\frac{1}{2}$ w			
R191	302-104	100 k	$\frac{1}{2}$ w			

†Concentric with SW160Y. Furnished as a unit.

Parts List—Type 22A

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R192	302-470	47 Ω	5%
R193	302-101	100 Ω	
R194	306-683	68 k	
R195	302-473	47 k	
R196	301-114	100 k	5%
R197	302-470	47 Ω	
R198	302-470	47 Ω	
R199	304-472	4.7 k	

Switches

	Unwired	Wired			
SW8	260-558	*262-578	Rotary	SOURCE	
SW10	260-145		Slide		7000-10999
SW10	260-0449-00		Slide		11000-up
SW22	260-212		Slide		7000-10999
SW22	260-0447-00		Slide	SLOPE	11000-up
SW101	260-518		Push w/Neon Bulb	RESET	
SW120	260-556	use*262-628	Rotary		7000-10999
SW120	260-0556-00	*262-0628-01	Rotary		11000-up
SW160	260-275	*262-577	Rotary		
SW160Y††	311-108			TIME/CM	

Transistors

Q24	151-120	2N2475		
Q34	151-120	2N2475		
Q44	*151-108	Tek Spec.		
Q104	151-055	2N398A		7001-7499
	151-071	2N1305		7500 up

Electron Tubes

V24	154-187	6DJ8		
V114	154-022	6AU6		
V115	154-187	6DJ8		
V125	154-022	6AU6		
V133	154-187	6DJ8		
V135	154-187	6DJ8		
V145	154-047	12BY7		
V152	*157-075	12AL5	checked	7000-11639
V152	154-0038-00	12AL5		11640-up
V161	154-040	12AU6		7000-11559
V161	154-0040-05	8426		11560-up
V173	154-187	6DJ8		
V183	154-187	6DJ8		
V193	154-187	6DJ8		

††Concentric with R160Y. Furnished as a unit.

1 BLOCK DIAGRAM

IMPORTANT

VOLTAGE and WAVEFORM MEASUREMENTS may vary somewhat between instruments due to normal manufacturing tolerances and component characteristics.

All circuit voltage readings are in volts.

Actual photographs of waveforms are shown.

All Waveforms and Voltage Readings were obtained under the following conditions unless otherwise noted on the specific diagrams:

DC Voltmeter Impedance	20,000 Ω /volt
Test Oscilloscope Bandpass	DC to 30 mc
Test Oscilloscope Triggering	+ Internal
Vertical Input Signal	None
Trigger Input Signal	None

Type 555

Control	Setting
AMPLITUDE CALIBRATOR	OFF
DELAYED TRIG. (1-10 MULT.)	5.00
FOCUS (Both Beams)	Ccw
INTENSITY (Both Beams)	Ccw
HORIZ. POSITION (Both Beams)	Centered
Upper Beam HORIZ. DISPLAY	TIME BASE A $\times 1$
Lower Beam HORIZ. DISPLAY	TIME BASE B $\times 1$
EXT. HORIZ. GAIN (Both Beams)	Ccw

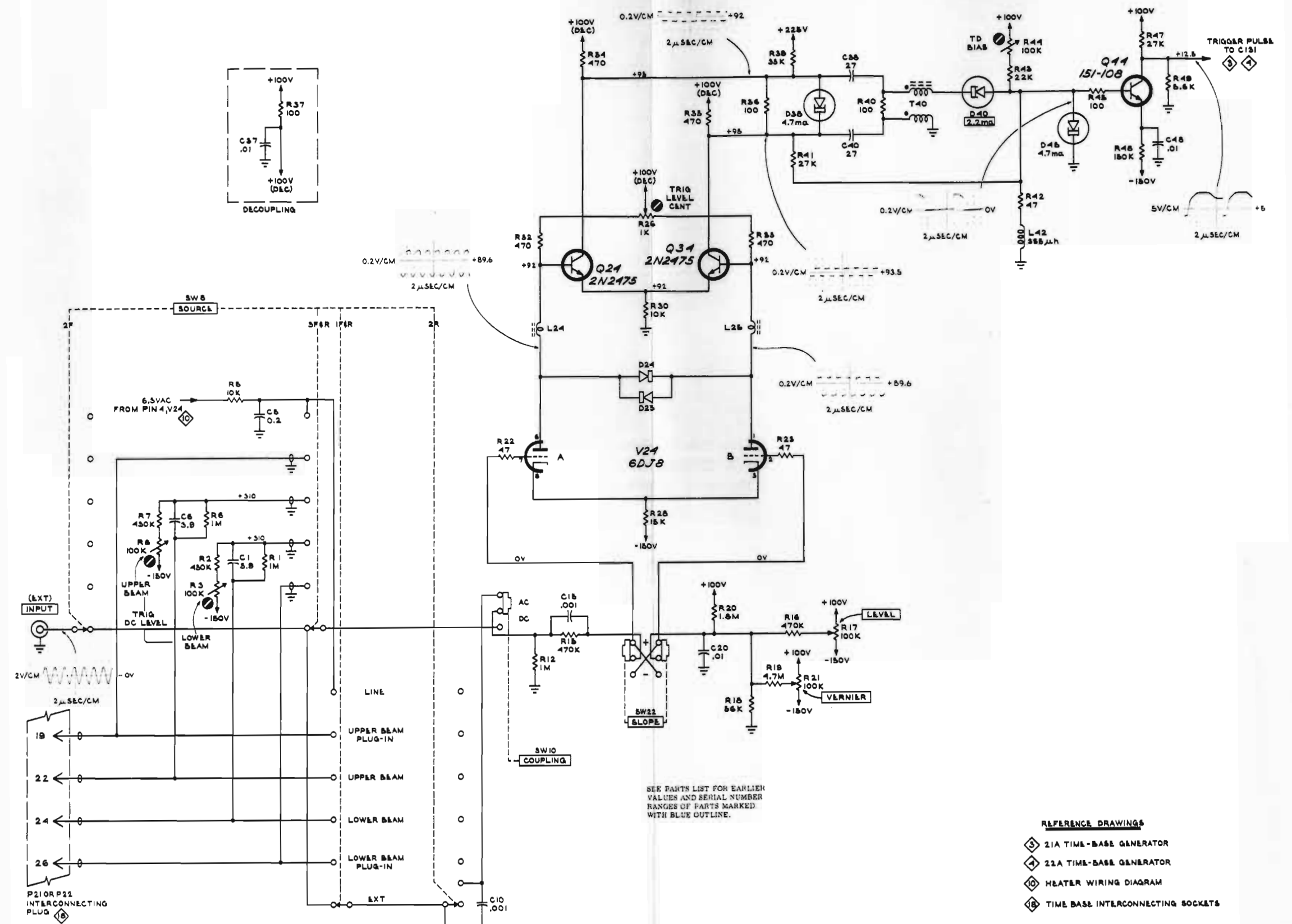
Type 21A and 22A

SWEEP FUNCTION	AUTO BASELINE
TIME/CM	10 μ SEC
SOURCE	EXT.
COUPLING	AC
SLOPE	+
LEVEL	Cw
VERNIER	Centered

2 TIME-BASE TRIGGER

WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:

Input Signal	5-volt 350-kc Sine Wave
LEVEL Control	Centered
Also see IMPORTANT note on Block Diagram.	

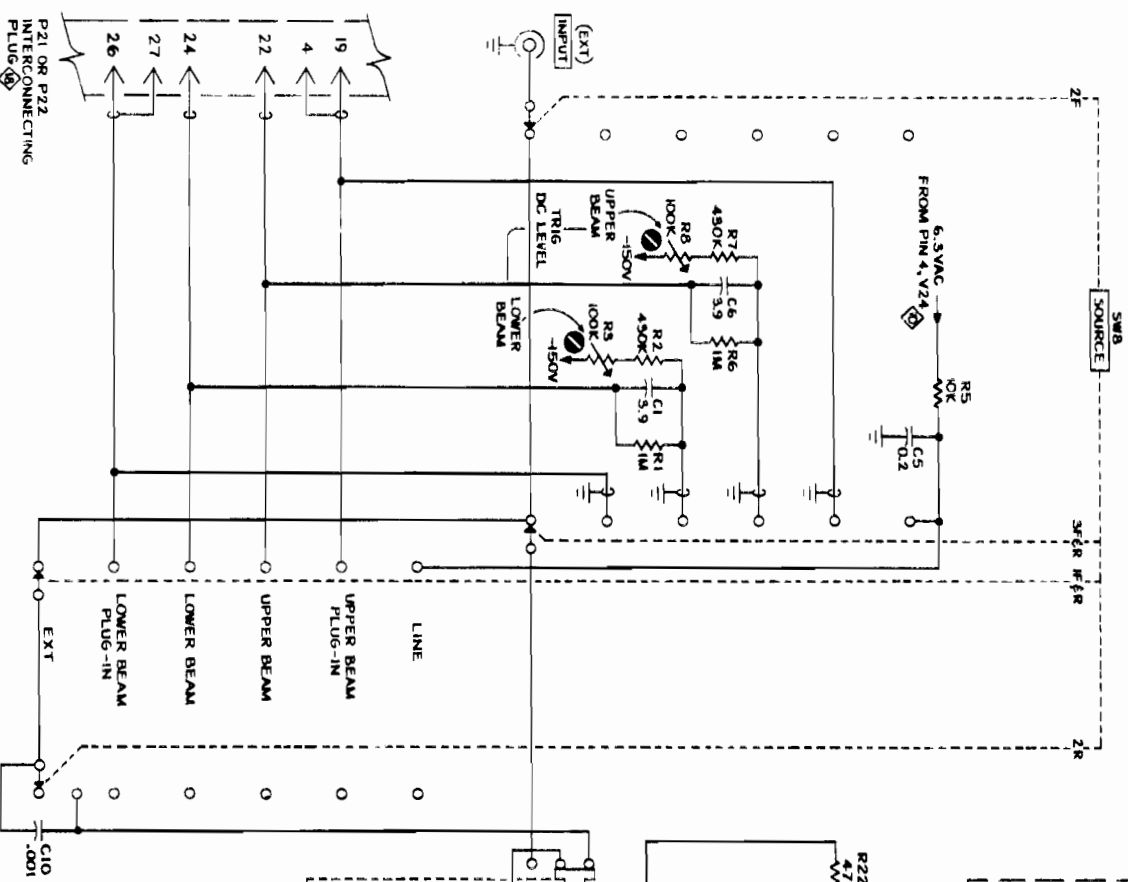


TYPE 21A TIME-BASE UNITS
TYPE 22A

AC1

CMD 166
TIME-BASE TRIGGER 2
S/N 7000-10999

7-79/7-80



4.7
TIME-BASE TRIGGER 2
S/N 11,000-UP

3 TIME-BASE GEN. TYPE 21A

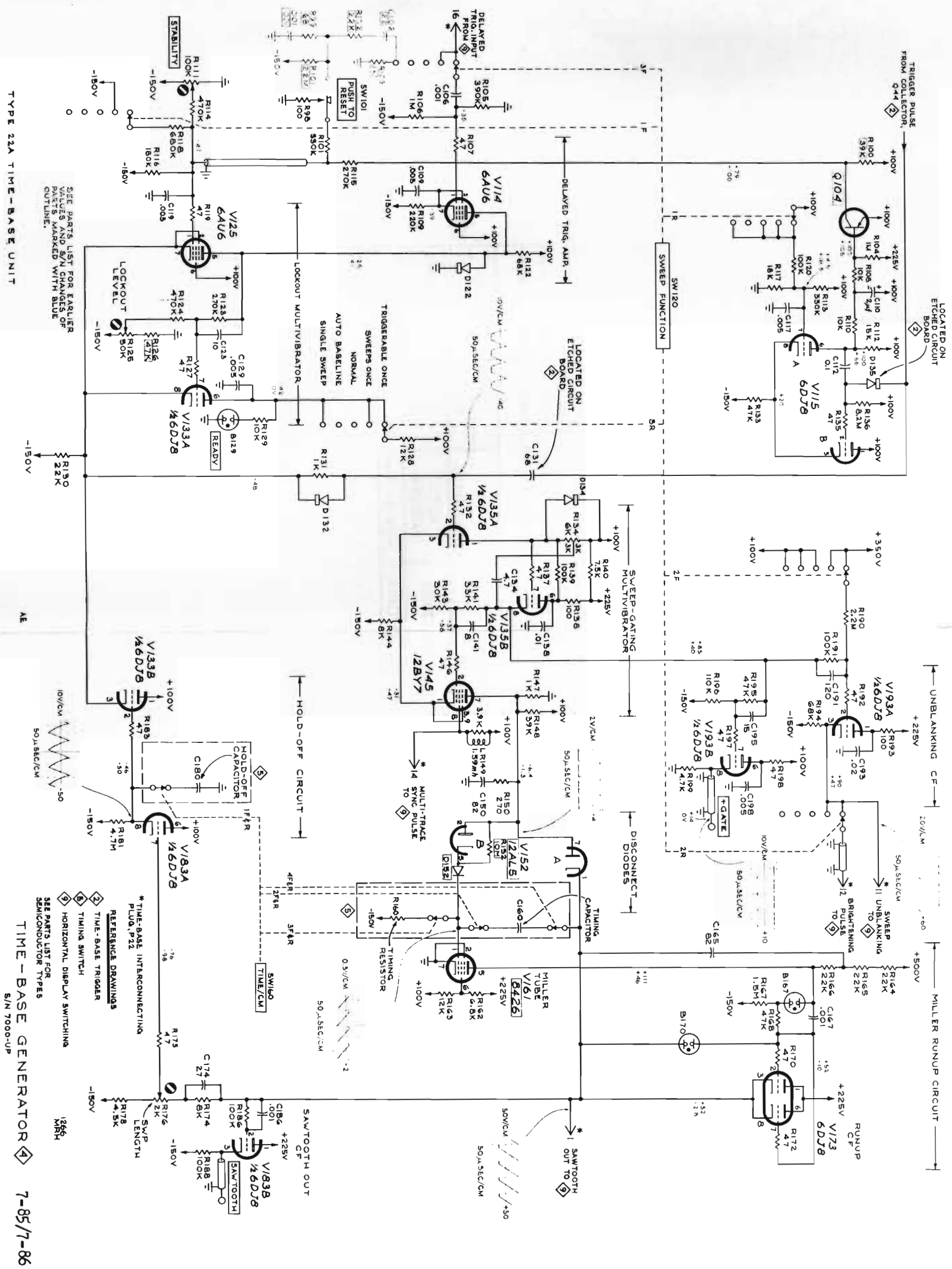
WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:			
	Waveforms	Voltage Readings	
		Upper	Lower
SWEEP FUNCTION	AUTO BASELINE	AUTO BASELINE	NORMAL
Also see IMPORTANT note on Block Diagram.			

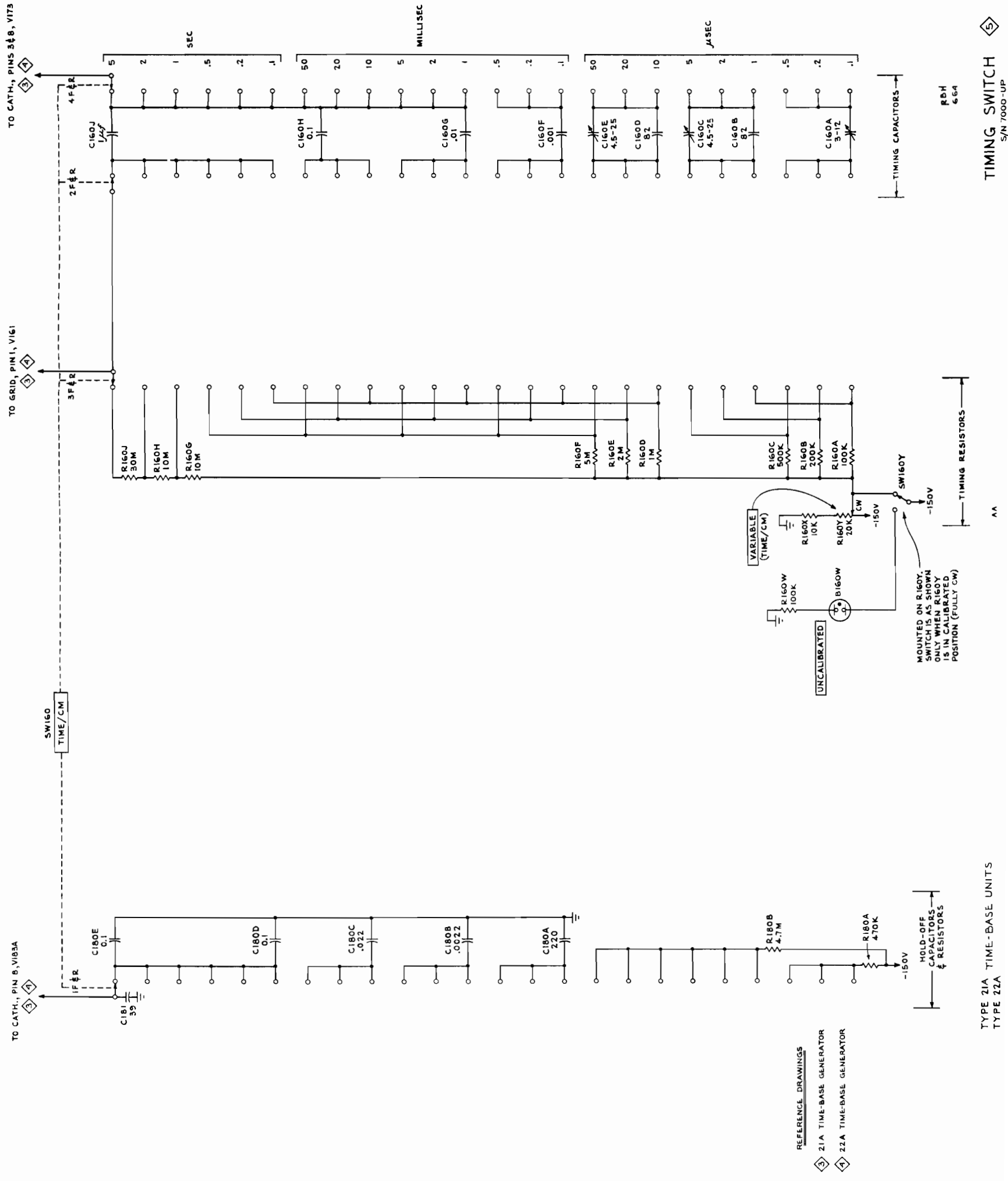
4 TIME-BASE GEN. TYPE 22A

WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:

	Waveforms	Voltage Readings	
		Upper	Lower
SWEEP FUNCTION	AUTO BASELINE	AUTO BASELINE	NORMAL

Also see IMPORTANT note on Block Diagram.





	TYPE 21A	TIME-BASE UNITS
TYPE 22A		

TIMING SWITCH
S/N 7000-UP

6 UPPER BEAM HORIZONTAL AMP.

WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:

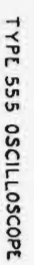
	Waveforms	Voltages	
		Upper	Lower
HORIZ. DISPLAY	TIME BASE A $\times 1$	EXT. ATTEN $\times 1$	EXT. ATTEN $\times 1$
HORIZ. POSITION	Centered	Ccw	Cw
Also see IMPORTANT note on Block Diagram.			

7 LOWER BEAM HORIZONTAL AMP.

WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:

	Waveforms	Voltages	
		Upper	Lower
HORIZ. DISPLAY	TIME BASE B $\times 1$	EXT. ATTEN $\times 1$	EXT. ATTEN $\times 1$
HORIZ. POSITION	Centered	Ccw	Cw

Also see IMPORTANT note on Block Diagram.

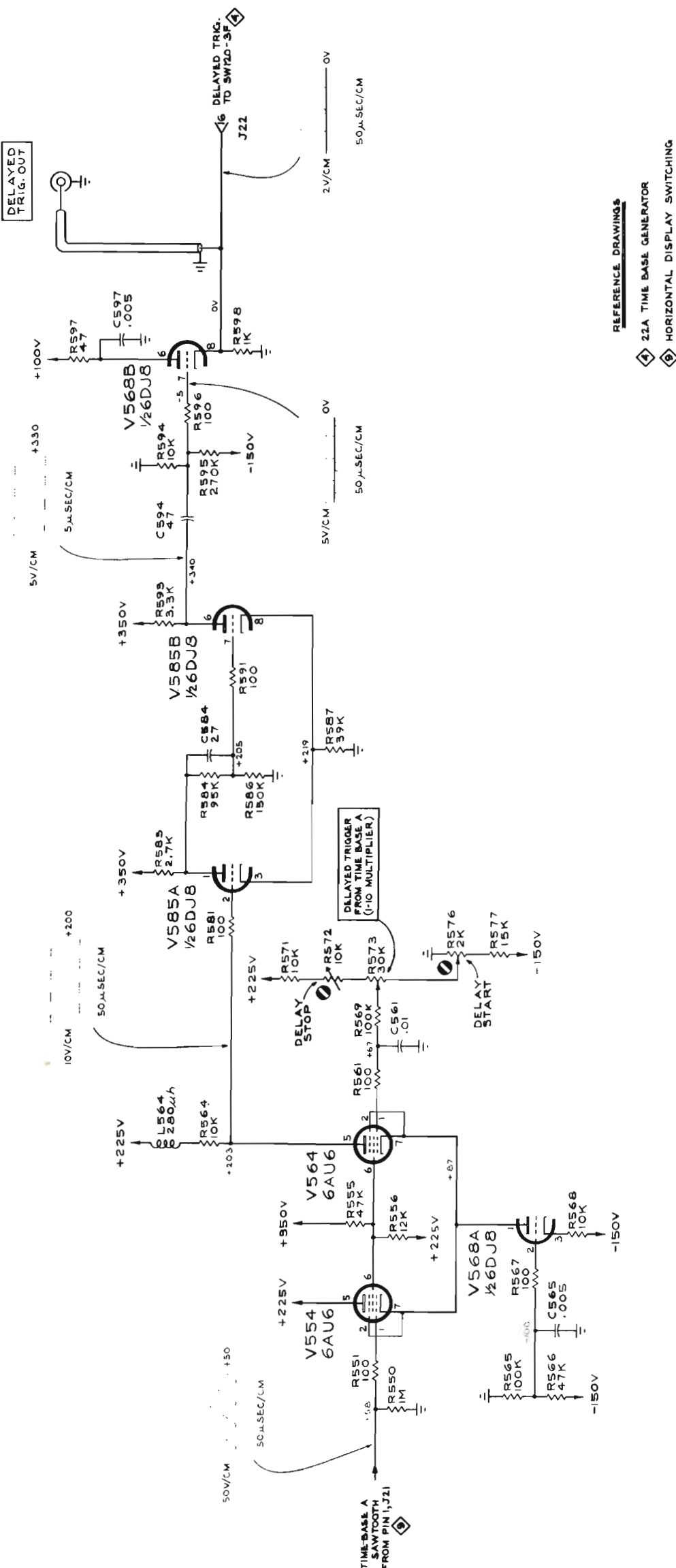


LOWER BEAM HORIZONTAL AMPLIFIER

7-91/7-92

8 DELAY PICKOFF

See IMPORTANT note on Block Diagram for WAVEFORM and VOLTAGE READING conditions.



TYPE 555 OSCILLOSCOPE

AA

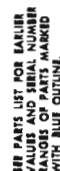
DELAY PICKOFF

S/N 7000-UP

9 HORIZ. DISPLAY SWITCHING

WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:

	Ext. Horiz. Amplifiers		Blanking Mixer and Chopped Blanking Amplifiers
	Waveforms	Voltages	
Ext. Horiz. Input Signal	'B' Sawtooth Applied thru 10X Probe	None	None
Upper Beam HORIZ. DISPLAY	EXT. ATTEN X 1	EXT. ATTEN X 1	TIME BASE A X 1
Lower Beam HORIZ. DISPLAY	EXT. ATTEN X 1	EXT. ATTEN X 1	TIME BASE B X 1
Type 22A SWEEP FUNCTION	AUTO BASELINE	AUTO BASELINE	SWEEPS ONCE FOR EACH 'A' DLY'D TRIG
Type 21A TIME/CM	10 μ SEC	10 μ SEC	1 μ SEC
Also see IMPORTANT note on Block Diagram.			



- 3 TYPE 2/A TIME BASE GENERATOR
- 4 TYPE 22A TIME BASE GENERATOR
- 5 UPPER BEAM HORIZONTAL AMPLIFIER
- 6 LOWER BEAM HORIZONTAL AMPLIFIER
- 7 CRT CIRCUIT
- 8 UPPER BEAM VERTICAL AMPLIFIER
- 9 LOWER BEAM VERTICAL AMPLIFIER
- 10 TIME BASE INTERCONNECTING SOCKETS
- 11 DELAY PICKOFF

10 LV POWER SUP. and HTR. WIRING

See IMPORTANT note on Block Diagram for VOLTAGE READING conditions.

NOTE

The regulated 6.3 volts ac can be read ONLY with an iron-vane or dynamometer-type rms-reading meter.

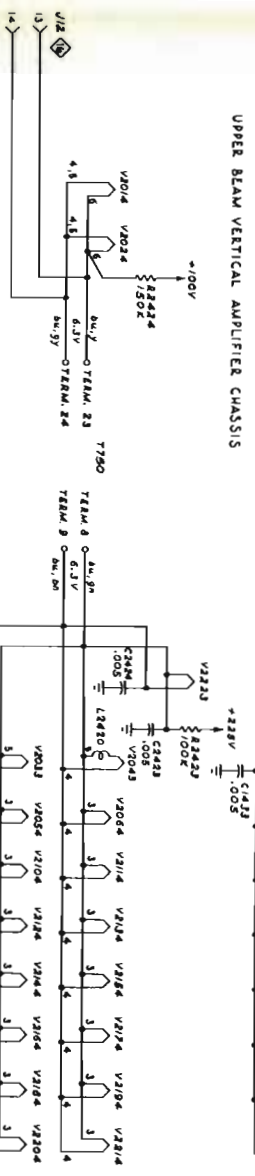
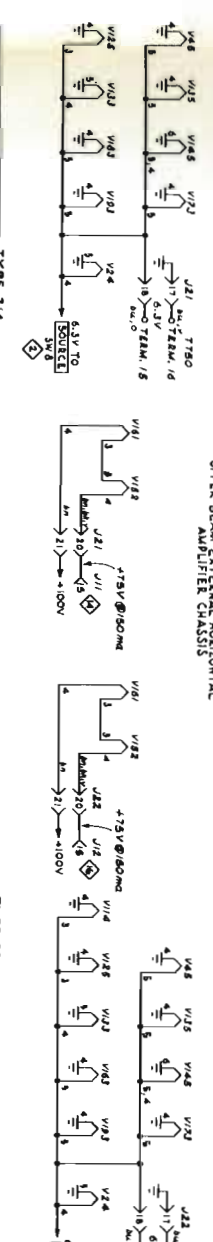
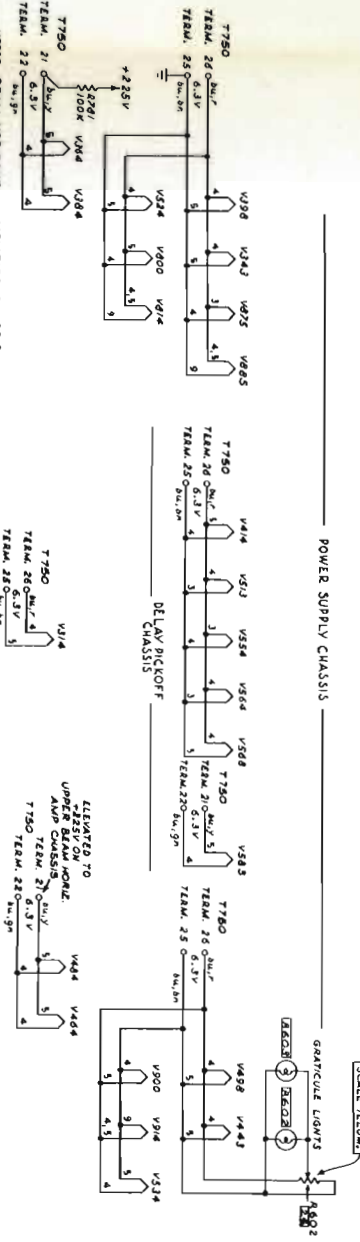
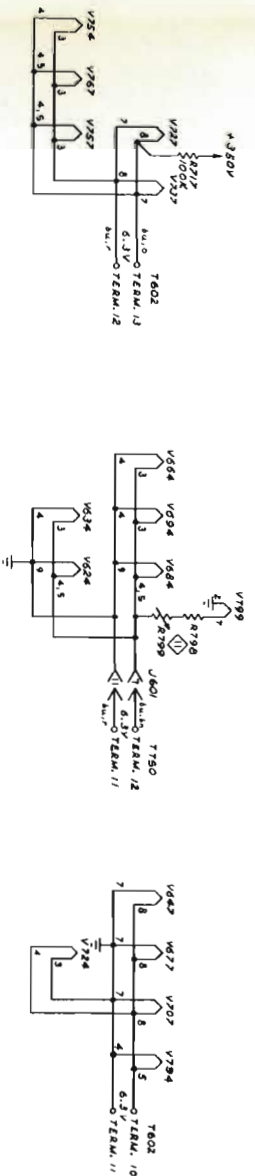
V3
4

T780
TERM.
TERM.

T780
TERM.
TERM.
— UPPH

V28
4

V28
4



11 DECOUPLING NETWORK

WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:

Probe ground connected to chassis.

Also see IMPORTANT note on Block Diagram.

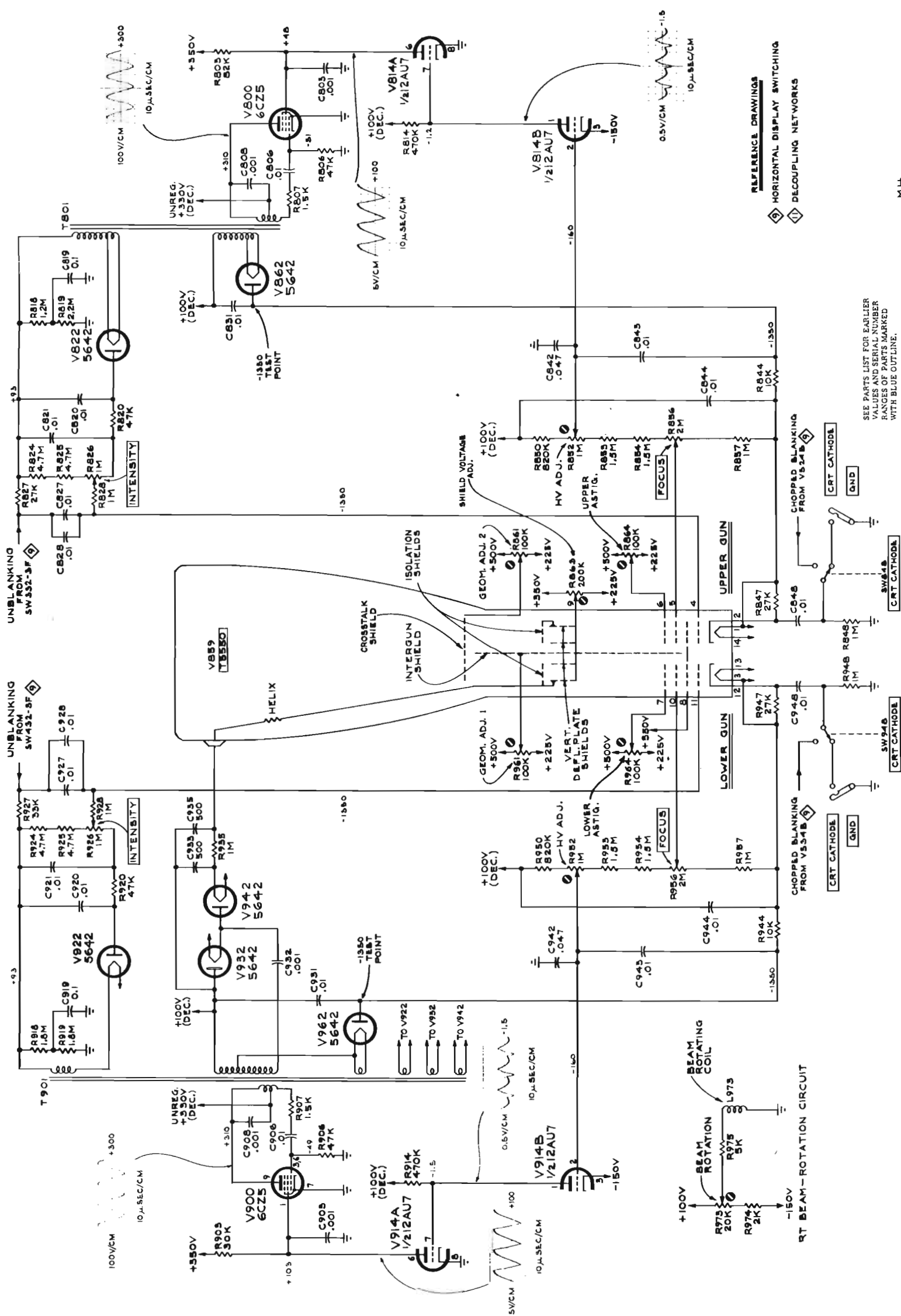
NOTE

The regulated 6.3 volts ac can be read ONLY with an iron-vane or dynamometer-type rms-reading meter.

All waveforms on this diagram are affected by the input line frequency waveform.

12 CRT CIRCUIT

See IMPORTANT note on Block Diagram for WAVEFORM and VOLTAGE READING conditions.



TYPE 555 OSCILLOSCOPE

AB

CRT CIRCUIT

MH
764

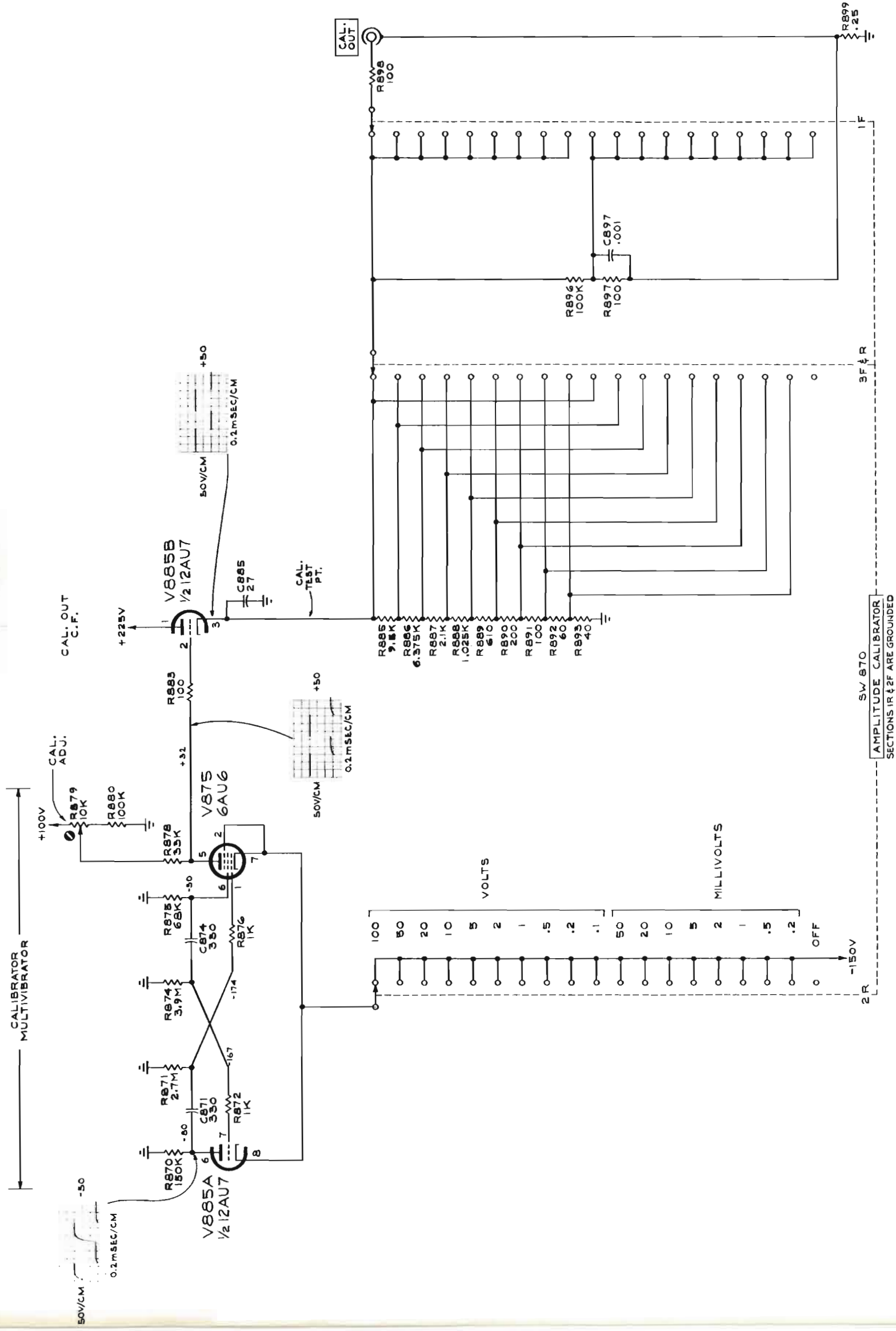
S/N 7000-UP

7-101/7-102

- REFERENCE DRAWINGS
- 9 HORIZONTAL DISPLAY SWITCHING
 - 11 DECOUPLING NETWORKS

SEE PARTS LIST FOR EARLIER
VALUES AND SERIAL NUMBER
RANGES OF PARTS MARKED
WITH BLUE OUTLINE.

13	AMPLITUDE CALIBRATOR	WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:
	AMPLITUDE CALIBRATOR	.2 MILLIVOLTS
	Also see IMPORTANT note on Block Diagram.	



TYPE 555 OSCILLOSCOPE

AA

AMPLITUDE CALIBRATOR (3)

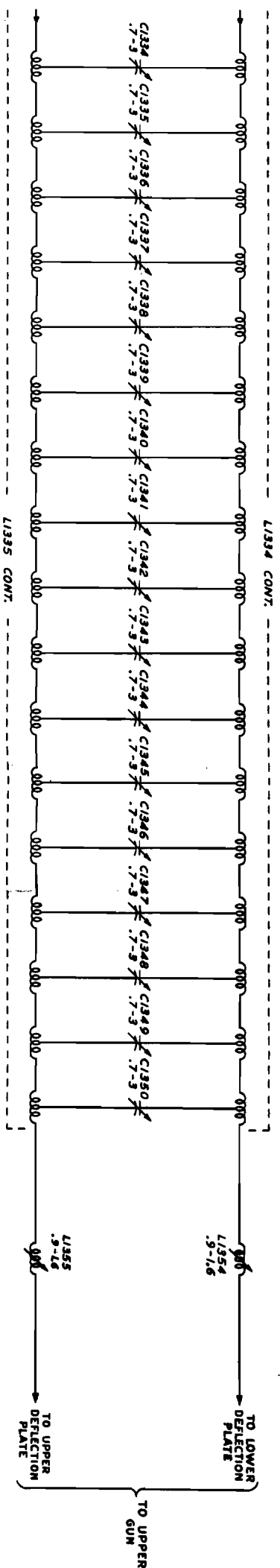
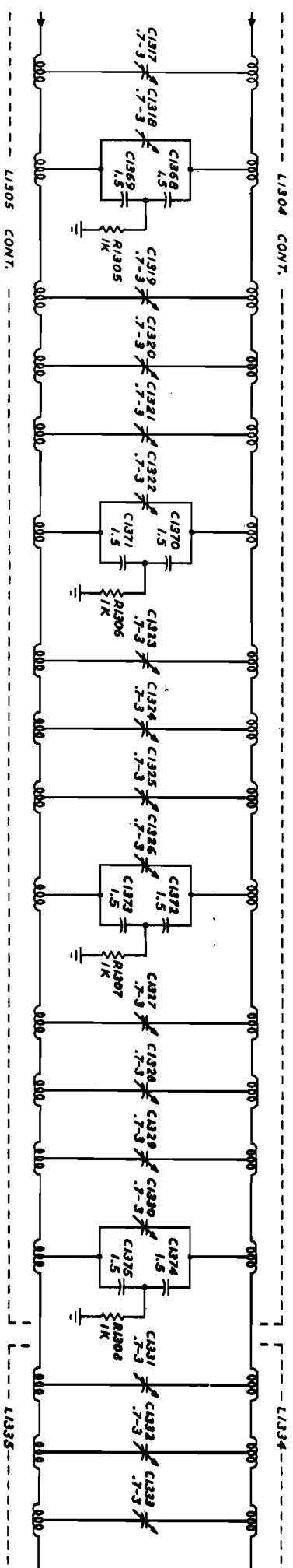
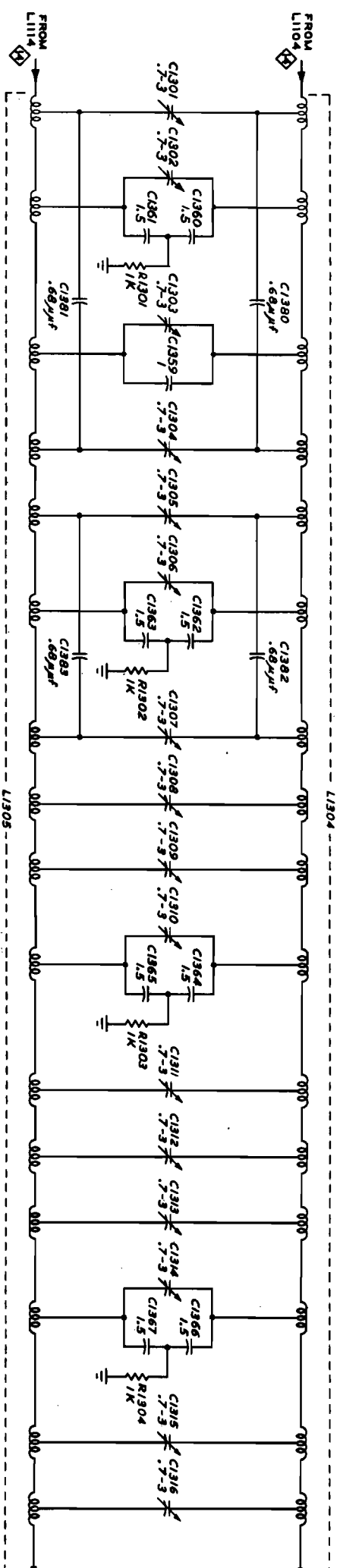
S/N 7000-UP

7-103/7-104

14 UPPER BEAM VERTICAL AMP.

WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:

	Waveforms	Voltages
Upper Beam Vertical Input	0.5-volt 1-kc Calibrator Signal	None
Plug-In Deflection Factor	0.05 volts/cm	
Also see IMPORTANT note on Block Diagram.		



REFERENCE DRAWINGS

UPPER BEAM VERTICAL AMPLIFIER

UPPER BEAM

qab

eca

TYPE 555 OSCILLOSCOPE

AA

DELAY LINE NETWORK

S/N 7000-UP

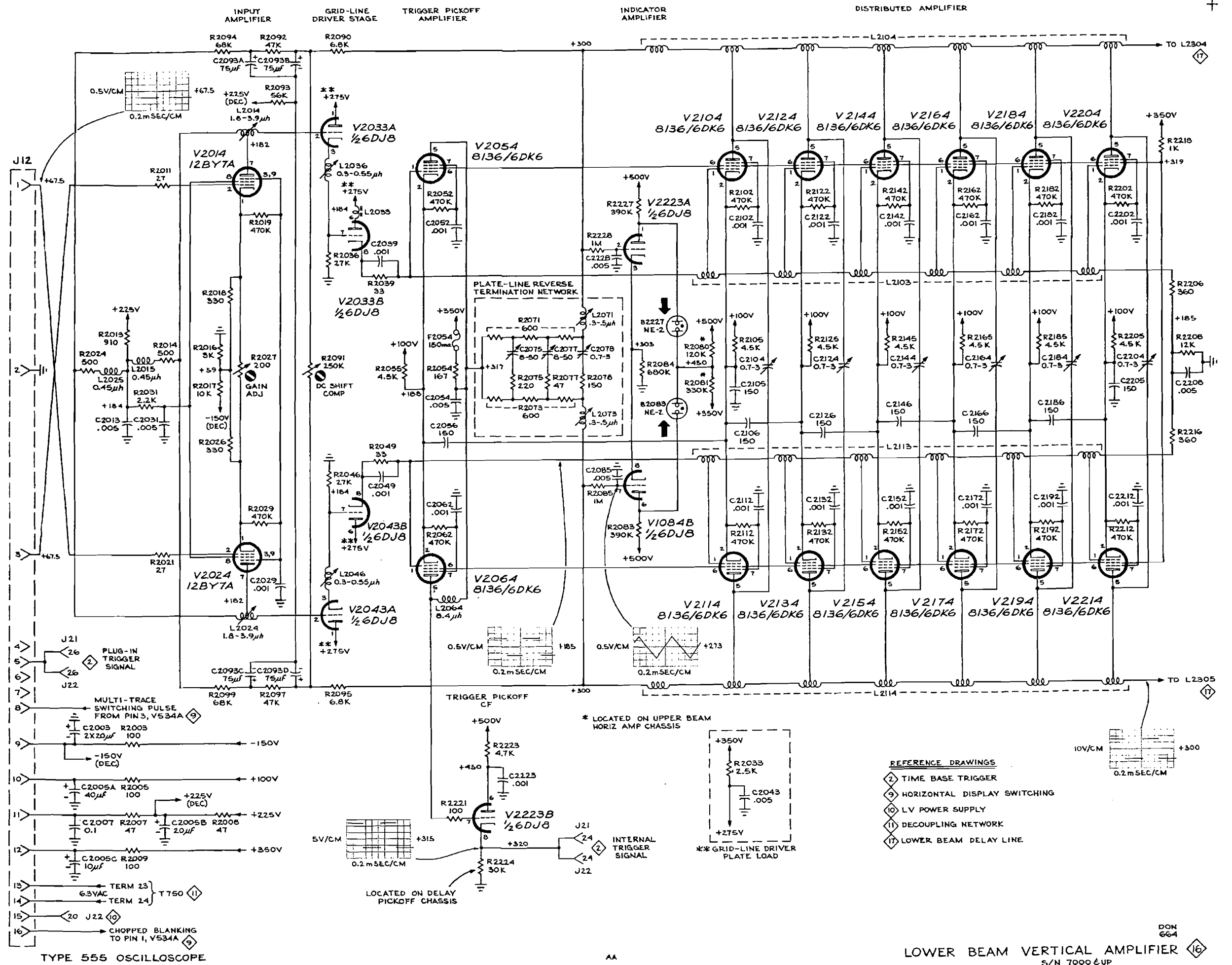
7-107/7-108

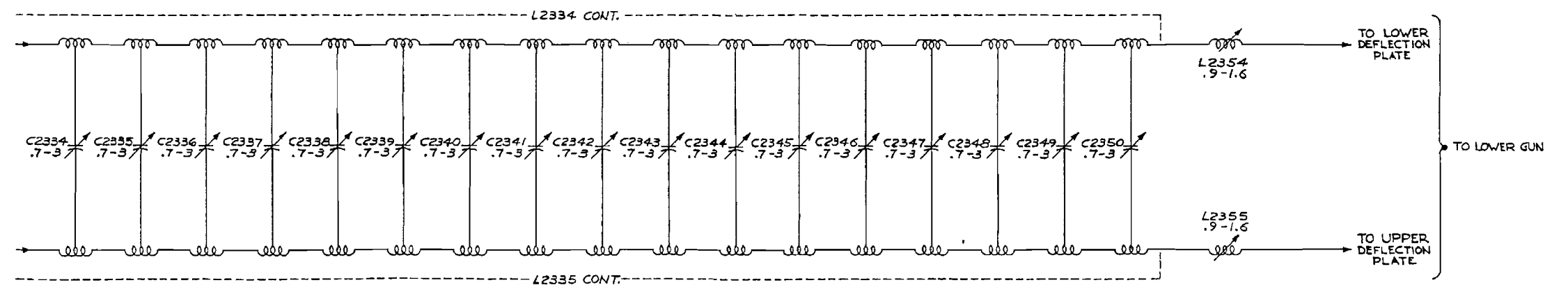
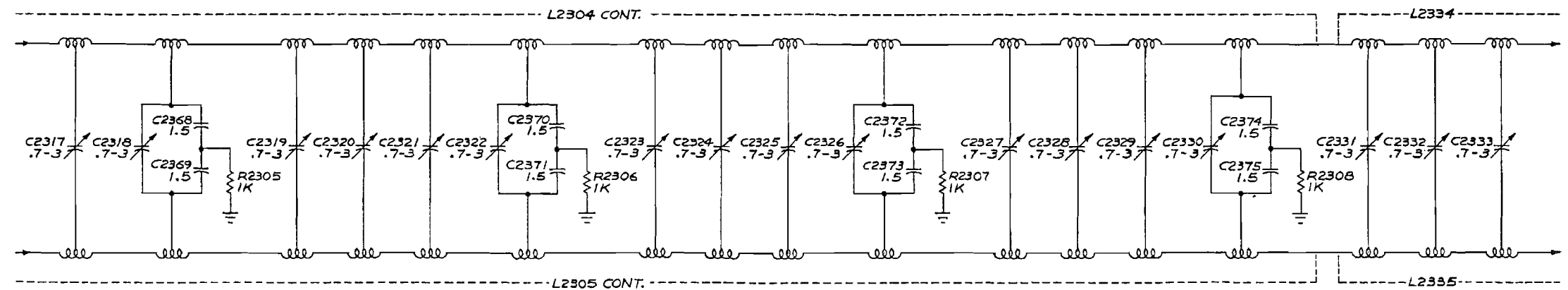
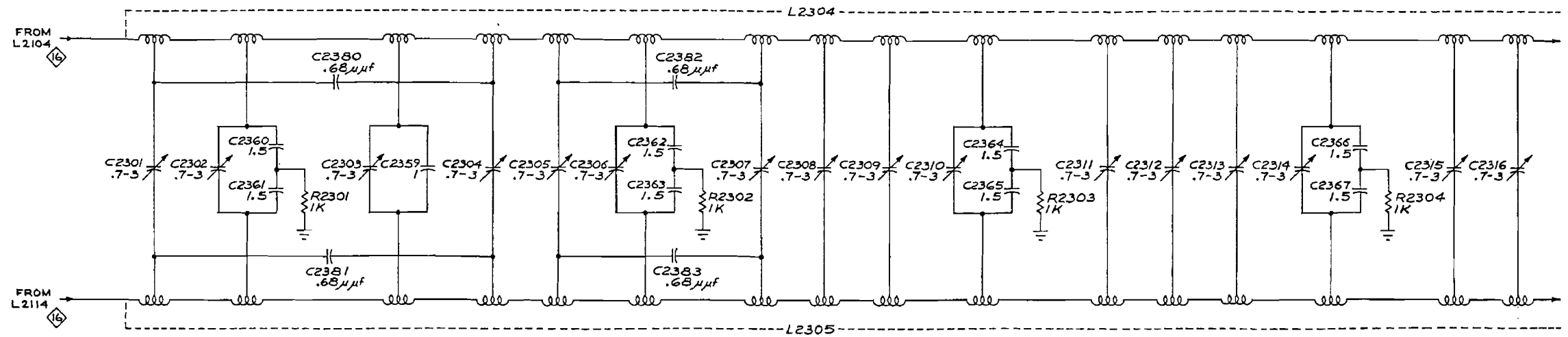
16 LOWER BEAM VERTICAL AMP

WAVEFORMS and VOLTAGE READINGS were obtained under the following conditions:

	Waveforms	Voltages
Lower Beam Vertical Input	0.5-volt 1-kc Calibrator Signal	None
Plug-In Deflection Factor	0.05 volts/cm	

Also see IMPORTANT note on Block Diagram.





REFERENCE DRAWINGS

16 LOWER BEAM VERTICAL AMPLIFIER

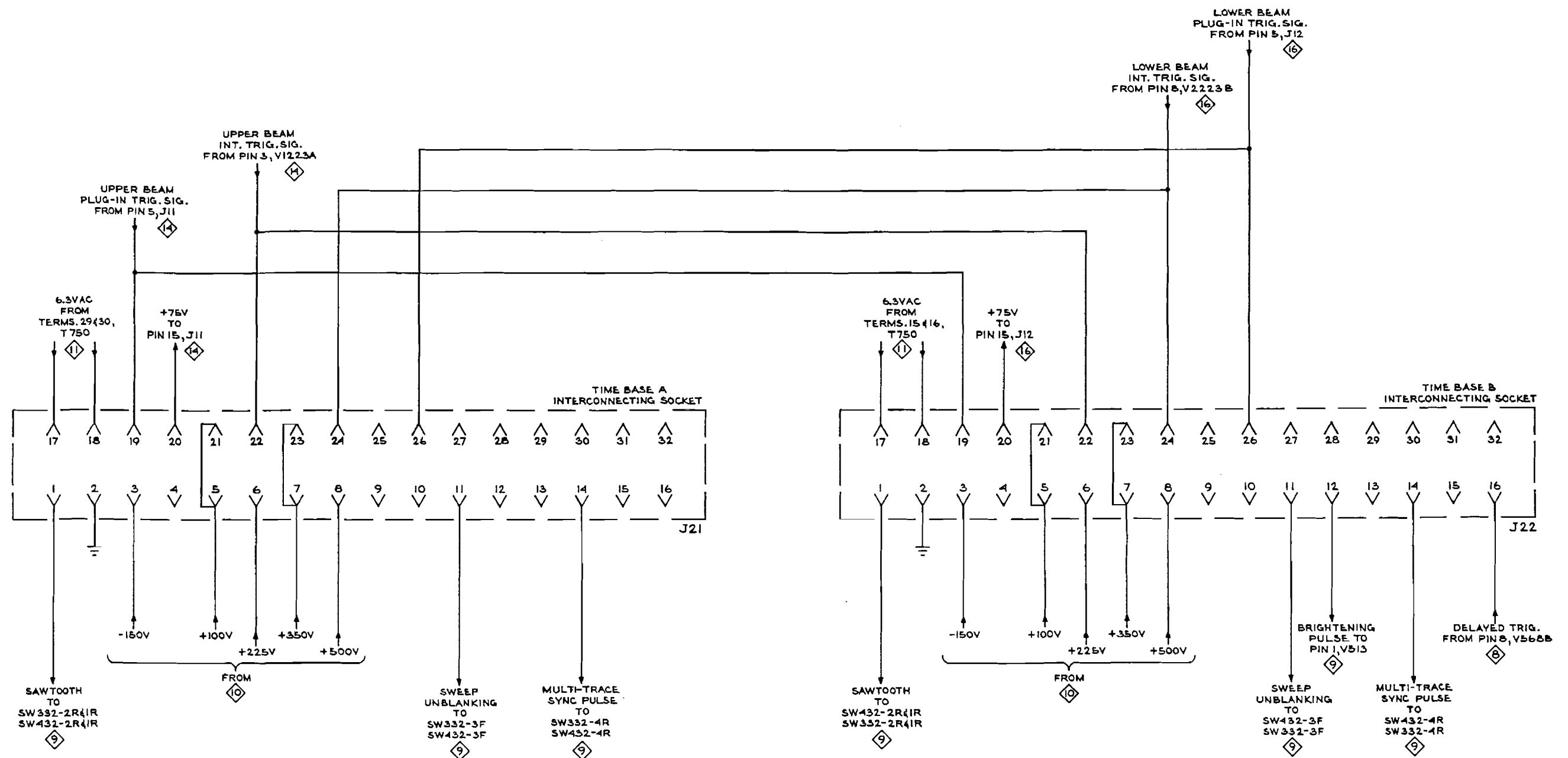
MH
664

TYPE 555 OSCILLOSCOPE

AA

LOWER BEAM
DELAY LINE NETWORK 17

S/N 7000-UP



REFERENCE DRAWINGS

- 8 DELAY PICKOFF
- 9 HORIZONTAL DISPLAY SWITCHING
- 10 LV POWER SUPPLY
- 11 DECOUPLING NETWORKS
- 14 UPPER BEAM VERTICAL AMPLIFIER
- 16 LOWER BEAM VERTICAL AMPLIFIER

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages. If it does not, your manual is correct as printed.

TYPE 555

TENT SN 12120

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

R826	311-0041-02
R856	311-0043-02
R926	311-0041-02
R956	311-0043-02

M11,639/368

7-117/7-118

TEXT CORRECTION

Section 2 Operating Instructions

Page 2-1 Column 2

CHANGE: the paragraph entitled "Transformer Conversion" with the following:

Unless otherwise indicated, the Type 555 is shipped with the power transformers, the saturable reactor, and the fan wired for a nominal line voltage of 117 volts ac, 50 to 60 cps. Proper regulation of the oscilloscope power supplies will be maintained at line voltages between 105 and 125 volts when the instrument is wired for a nominal line voltage of 117 volts, and within proportional limits when it is wired for other nominal line voltages.

The power transformers and the saturable reactor in the Type 555 have two primary windings. Wiring the two primary windings in parallel enables the instrument to be used with a nominal line voltage of 117 volts ac. Wiring the primary windings in series enables the instrument to be operated with a nominal line voltage of 234 volts ac.

In instruments SN9480 and above the Power Supply Unit power transformers (T601 and T602) have two additional windings, called buck-boost windings, which enable the instrument to be operated on nominal line voltages of 110, 117, 124, 220, 234, and 248 volts. In instruments SN10399 and above the Indicator Unit regulated heater transformer T750 also has the buck-boost windings. Selected instruments below SN 10399 were modified out of sequence. These instruments have the additional buck-boost windings on T750. It is possible to tell if your instrument is one of those modified out of sequence by looking at the primary connections on the power transformer (see Fig. 1(a)). If the primary connections (terminals 1, 2, 3, and 4) have four terminals labeled A, B, C, and D near them as shown in Fig. 1(a) the transformer has the buck-boost windings and may be wired for any of the nominal line voltages as shown in Fig. 1(b). If terminals A, B, C, and D

are not present the only nominal line voltages for which the transformer may be wired are 117 volts and 234 volts. Fig. 1(b) may be used as a connection guide for transformers without buck-boost windings by using only the 117-volt and 234-volt diagrams and ignoring the terminals labeled A, B, C, and D.

When changing the instrument from operation on one nominal line voltage to operation on another, the connections to T601 and T602 (in the Power Supply Unit) and to T750 (in the Indicator Unit) must be changed. The proper transformer connections for the various nominal line voltages are shown in Fig. 1(b).

NOTE

A metal tag is mounted on the rear of the Power Supply Unit which indicates the original nominal line voltage. If the primary wiring is changed, reverse the tag so that the blank side may be marked to indicate the nominal line voltage.

Whenever an instrument is changed from 110-, 117-, 124-volt operation to 220-, 234-, 248-volt operation the fan connections and the connections on L790 in the Power Supply Unit must be changed. Fig. 2(a) shows the fan connections for 110-, 117-, 124-volt operation and Fig. 2(b) shows the fan connections for 220-, 234-, 248-volt operation. To change from 110-, 117-, 124-volt operation to 220-, 234-, 248-volt operation the central buss wire (see Fig. 2(a)) is straightened and moved to the notch between the two heavy black fan leads. Then the fan lead which is attached to the end notch on the ceramic strip is moved toward the other fan lead one notch, to the notch in which the central buss wire was placed. The correct fan connections for 220-, 234-, 248-volt operation are shown in Fig. 2(b).

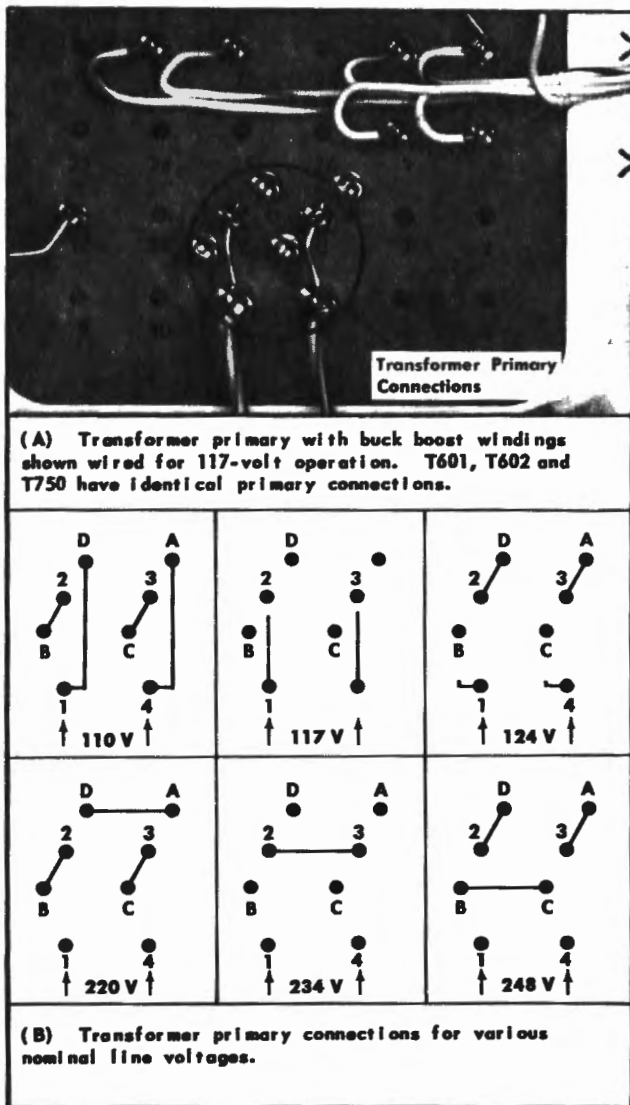


Fig. 1. Power Transformer connections.

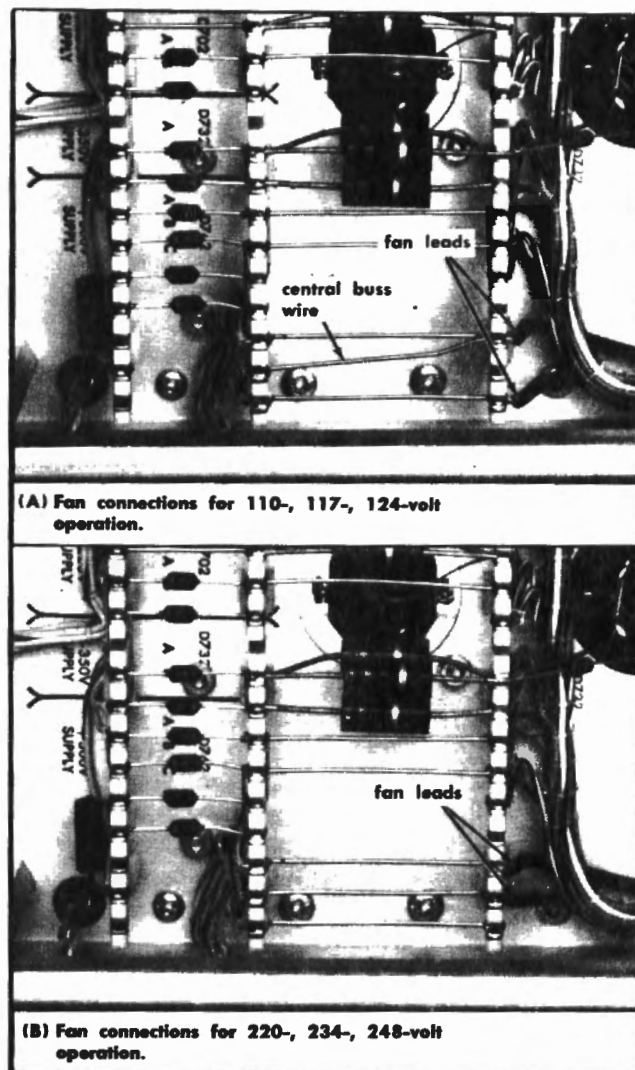


Fig. 2. The fan connections are located in the Power Supply Unit between T601 and L790.

To change the fan connections from 220-, 234-, 248-volt operation to 110-, 117-, 124-volt operation the heavy black fan lead which is nearest to the edge of the chassis is moved to the end notch in the ceramic strip. The buss wire to which it was connected is then bent and connected to the other fan lead. The correct fan connections for 110-, 117-, 124-volt operation are shown in Fig. 2(a).

L790 connections for both 110-, 117-, 124-volt operation and 220-, 234-, 248-volt operation are shown in Fig. 3.

Fuse data for both 110-, 117-, 124-volt operation and 220-, 234-, 248-volt operation is silk-screened on the rear of the Power Supply Unit. Fuse data is also given in the Electrical Parts List.

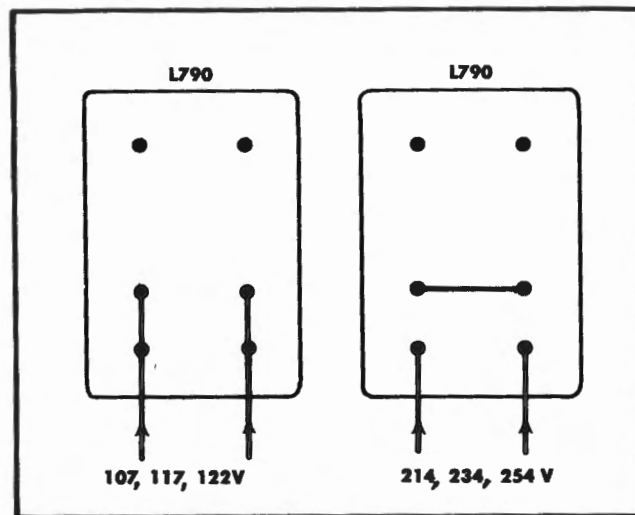


Fig. 3. Connections to L790 for both 107, 117, 127 volt operation and 214, 234 and 254 volt operation.

TYPE 555 TEST SN 11430

PARTS LIST CORRECTION

CHANGE TO:

R617

308-0186-01

80 kΩ

1 W

WW

1%

TYPE 555 TENT SN 12110

PARTS LIST CORRECTION

CHANGE TO:

C480

290-0405-00

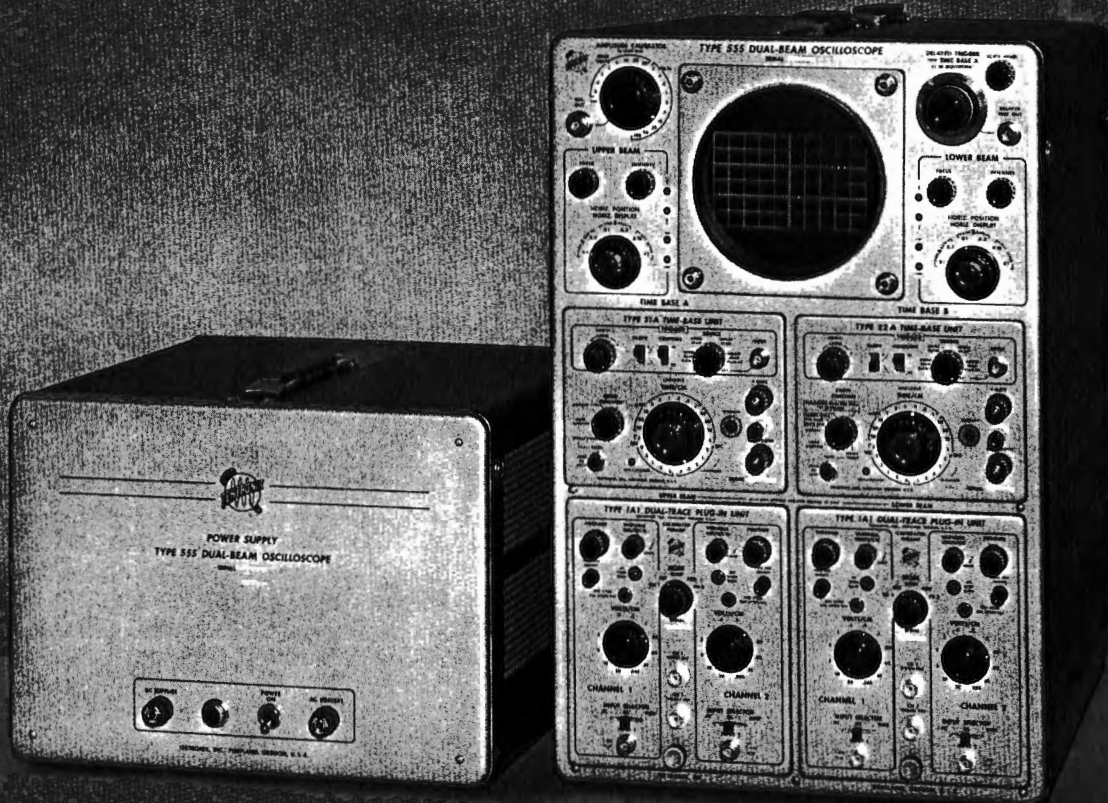
10 μ F

EMT

150 V



DC-to-33 MHz DUAL BEAM OSCILLOSCOPE with SWEEP DELAY Type 555



- ILLUMINATED NO-PARALLAX GRATICULE
- ACCEPTS AMPLIFIER, SPECTRUM ANALYZER, AND SPECIAL-PURPOSE PLUG-INS
- CALIBRATED SWEEP DELAY
- DUAL-BEAM DISPLAYS

The Type 555 Oscilloscope is a dual-beam laboratory instrument for accurate measurements in the DC to 33 MHz range. Two complete horizontal-deflection systems and two independent vertical amplifiers provide for completely independent deflection of the two beams.

Either of two plug-in time base units can control the sweep of either or both electron beams. In addition, a continuously-variable calibrated sweep delay allows expansion of a selected portion of the undelayed sweep for precise time measurements. Delayed and undelayed sweeps can be presented simultaneously.

The wide-band main amplifiers in the Type 555 are designed to accept Letter-Series and 1-Series Plug-In Units for a high degree of signal-handling versatility.

CHARACTERISTIC SUMMARY VERTICALS

2 identical vertical-deflection systems

Letter-Series and 1-Series Plug-In Units offer wide selection of vertical-deflection characteristics for both beams.

HORIZONTALS

2 independent horizontal-deflection systems

CALIBRATED SWEEP RANGE—0.1 μ s/cm to 5 s/cm.

SWEEP MAGNIFIER—5X, extends sweep range to 0.02 μ s/cm.

CALIBRATED SWEEP DELAY—0.1 μ s to 50 s.

TRIGGER REQUIREMENTS—Internal: 2-cm deflection to 33 MHz.

External: 0.5 V to 10 MHz, 1.5 V to 33 MHz.

EXTERNAL INPUT—0.2 to 20 V/cm; DC to 350 kHz; 1 meg-ohm, 47 pF (approx).

CRT

ILLUMINATED NO-PARALLAX GRATICULE

DISPLAY AREA—4 x 10 cm (each beam), 2-cm overlap.

ACCELERATING VOLTAGE—10 kV.

OTHER CHARACTERISTICS

AMPLITUDE CALIBRATOR—0.2 mV to 100 V, 1-kHz square-wave.

POWER REQUIREMENTS—105 to 125 V, or 210 to 250 V, 50 to 60 Hz, 1050 watts maximum.

VERTICAL PLUG-IN UNITS (Bandwidth is specified at -3 dB.)			
PLUG-IN UNIT	CALIBRATED DEFLECTION FACTOR	BANDWIDTH	RISETIME
<i>For Wide-Band, Multiple Trace Applications</i>			
1A1 Dual-Trace	50 mV/cm to 20 V/cm	DC to 33 MHz	10.5 ns
	5 mV/cm	DC to 23 MHz	15 ns
	≈500 μ V/cm	2 Hz to 14 MHz	25 ns
1A2 Dual-Trace	50 mV/cm to 20 V/cm	DC to 33 MHz	10.5 ns
CA Dual-Trace	50 mV/cm to 20 V/cm	DC to 24 MHz	15 ns
M Four-Trace	20 mV/cm to 10 V/cm	DC to 20 MHz	17 ns
<i>For Wide-Band Applications</i>			
B	50 μ V/cm to 20 V/cm	DC to 20 MHz	18 ns
	5 mV/cm to 50 mV/cm	2 Hz to 12 MHz	30 ns
K	50 mV/cm to 20 V/cm	DC to 30 MHz	12 ns
L	50 mV/cm to 20 V/cm	DC to 30 MHz	12 ns
	5 mV/cm to 2 V/cm	3 Hz to 24 MHz	15 ns
<i>For Differential Input Applications</i>			
1A7 High-Gain	10 μ V/cm to 10 V/cm	DC to 500 kHz	0.7 μ s
D High Gain	1 mV/cm (to 50 mV/cm)	DC to 300 kHz (DC to 2 MHz)	
E Low-Level	50 μ V/cm (to 10 mV/cm)	0.06 Hz to 20 kHz	
		(20 kHz to 60 kHz)	
G Wide-Band	50 mV/cm to 20 V/cm	DC to 20 MHz	18 ns
<i>For High DC Sensitivity Applications</i>			
H Wide-Band	5 mV/cm to 20 V/cm	DC to 15 MHz	23 ns
<i>For Spectrum Analysis</i>			
1L10, 1L20, 1L30 Units cover 1-10,500 MHz			
<i>For Integration, Differentiation, Function Generation, Linear and Non-Linear Uses</i>			
O Operational Amplifier	50 mV/cm to 20 V/cm	DC to 25 MHz	14 ns
<i>For Transducer and Strain Gage Uses</i>			
Q	10 μ strain/div to 10 k μ strain/div	DC to 6 kHz	60 μ s
<i>For Transistor-Risetime Checks</i>			
R	0.5 mA/cm to 100 mA/cm		12 ns
<i>For Diode Recovery Time Measurements</i>			
S	0.05 V/cm and 0.5 V/cm		12 ns
<i>For Precise Amplitude Measurements Via Slide-Back</i>			
W	1 mV/cm to 50 mV/cm	DC to 8 MHz to DC to 23 MHz	44 ns to 15 ns
Z	50 mV/cm to 25 V/cm	DC to 13 MHz	27 ns
<i>High-Frequency Sampling Applications</i>			
1S1	2 mV/cm to 200 mV/cm	Equiv to 1.0 GHz	350 ps
1S2	5 mV/cm to 500 mV/cm	Equiv to 3.9 GHz	90 ps

VERTICAL-DEFLECTION SYSTEMS

IDENTICAL MAIN AMPLIFIERS provide 10.5-ns risetime and DC-to-33 MHz (3-dB down) when used with the Type 1A1 or 1A2 Plug-In Units. In addition, any Tektronix Letter-Series or Spectrum Analyzer Plug-In Units can be used in the Type 555 Oscilloscope.

PASSIVE PROBES supplied with the Type 555 reduce loading on the circuit under test and attenuate the signal by a factor of 10. Input RC becomes 10 megohms paralleled by approximately 7 pF with Type 555 and Type 1A1 or 1A2 Unit. Excellent transient response is retained, as the probes introduce no overshoot or ringing, but frequency response is down an additional 1 dB at 33 MHz.

SIGNAL DELAY permits observation of the leading edge of the waveform that triggers the sweep. A 0.2 μ s delay is introduced into each channel by the balanced (push-pull) delay networks.

HORIZONTAL-DEFLECTION SYSTEMS

PLUG-IN TIME-BASE UNITS incorporate Miller runup type sweep generators and inverse feedback in the timing circuits to assure excellent sweep linearity. The plug-in design of the Type 21A and 22A Time-Base Units provides easy access to all components for ease in maintenance. The Type 22A Time Base is identical to the Type 21A Time Base except for additional sweep-delay capabilities.

SWEEP RANGE from 0.1 μ s/cm to 5 s/cm is in 24 calibrated steps with 1-2-5 sequence. Accuracy is typically within 1% of full scale, and in all cases within 3%. Sweep range is continuously variable uncalibrated from 0.1 μ s/cm to 12 s/cm. An indicator light warns the operator when the sweep is uncalibrated.

5X SWEEP MAGNIFIER expands the center 2-cm portion of the normal display to fill 10 cm, and can be used to increase the calibrated sweep time to 0.02 μ s/cm. Any one-fifth of the magnified sweep can be displayed. Accuracy is within 5% of the displayed portion of the magnified sweep.

SINGLE SWEEP OPERATION facilitates photographic recording of waveforms. A RESET pushbutton arms the sweep to fire on the next received trigger. After firing once the sweep is locked out until rearmed by pressing the RESET button. The READY light indicates when the sweep is armed to fire on the next received trigger.

AUTOMATIC BASELINE SWEEP MODE provides a bright reference trace (regardless of sweep speed) when no input signal is applied, or when the input signal repetition rate is less than 20 Hz. Above 20 Hz, the time base is triggered at the repetition rate of the incoming trigger signal to achieve jitter-free displays to beyond 33 MHz.

EXTERNAL HORIZONTAL INPUTS provide for horizontal deflection of either beam with an external source. Inputs are at the rear of the oscilloscope. Horizontal deflection factor is continuously variable from 0.2 V/cm to approximately 20 V/cm. Bandwidth is DC to 350 kHz at minimum deflection factor. Input RC is 1 megohm paralleled by approximately 47 pF.

TRIGGER

TRIGGER LEVEL adjusts to allow sweep triggering at any selected point on either the rising or falling portion of the waveform. Main level control operates over a ± 10 V range; fine control adjusts over ± 1 V range.

TRIGGER SOURCE can be internal, external, or line, and can be AC or DC coupled. Internally, either sweep can be triggered from the upper or lower beam, or directly from either vertical plug-in unit. The latter permits direct triggering from a single channel of Types 1A1 and 1A2 Tektronix multi-trace plug-in units.

TRIGGER REQUIREMENT is 0.5-cm deflection for internal signals from DC to 5 MHz (approx 20 Hz to 5 MHz using automatic baseline, 2-cm deflection to 33 MHz (using Type 1A1 or 1A2 Plug-In Preamplifier). For external signals, 0.5 V is required for reliable triggering to 5 MHz and 1.5 V is required to 33 MHz. When AC-coupled, the low-frequency 3-dB point is approximately 160 Hz.

SWEEP DELAY

CALIBRATED DELAY RANGE from 0.1 μ s to 50 s is derived from the TIME BASE A Plug-In Unit and can be used to delay the start of any TIME BASE B sweep. The 24 calibrated steps are those described for the Type 21A and 22A Time Base Units, and are accurate within 3% of panel reading and within 3% of each other. A ten-turn precision potentiometer permits calibrated delay-time adjustments to any value from 0.1 μ s to 50 s with accuracy within 3%. Incremental accuracy of this control is within 0.2% on all ranges. For extreme accuracy, any of the calibrated steps can be adjusted to the accuracy of an external standard.

TRIGGERED OPERATION holds off the start of the delayed sweep until the arrival of the first trigger signal following the selected delay time. Because the delayed sweep is actually triggered by the signal under observation, the display is completely jitter free. A steady display is thus provided for time-modulated pulses and signals with inherent jitter.

CONVENTIONAL OPERATION holds off the start of the delayed sweep for the precise amount of selected delay time. Any time-modulation or jitter on the signal will be magnified in proportion to the amount of sweep expansion.

The time jitter in the delayed trigger or delayed sweep will not exceed one part in 20,000 of maximum available delay interval (where this interval is 10 times the Time/cm or Delay-Time setting).

HIGH SWEEP MAGNIFICATION is readily accomplished when TIME BASE B is operated at a faster rate than TIME BASE A. For example, if TIME BASE A is operating at 50 μ s/cm and TIME BASE B is operating at 1 μ s/cm, the magnification is 50 times. Both the original and magnified displays can be viewed simultaneously when the signal is introduced into both vertical channels, so that both beams are deflected.

TRACE BRIGHTENING indicates the exact portion appearing on the magnified display, and shows the point-in-time relationship of the magnified display to the original display.

DELAYED TRIGGER used to start the delayed sweep is available at the front panel, and can be used to trigger external equipment at any delay from 0.1 μ s to 50 s. Amplitude is approximately 5 V.

CRT AND DISPLAY FEATURES

TEKTRONIX DUAL-BEAM CRT is a 5" metalized tube with separate vertical and horizontal deflection plates for each beam. Each beam has a linear display area of 4 by 10 cm, with at least 2-cm overlap. For best results over the wide sweep range of the Type 555, a P2 phosphor is normally supplied. 10-

kV accelerating potential assures bright displays when using fast sweeps at low repetition rates, and in single-sweep applications.

ILLUMINATED NO-PARALLAX GRATICULE is edge lighted and is marked in 6 vertical and 10 horizontal centimeters.

CRT CONTROLS include separate focus and intensity adjustments for each beam. A screw-driver adjustment is provided for magnetic alignment of the traces to the graticule.

BEAM POSITION INDICATORS light to show the direction of each electron beam when it is not on the screen.

ILLUMINATED GRATICULE with variable edge lighting is accurately ruled in centimeter squares. Viewing area is 6 by 10 cm. Vertical and horizontal centerlines for each beam are further marked in 2-mm divisions for convenience in making time and amplitude measurements.

MULTI-TRACE BLANKING eliminates switching transients from the display when a multiple-trace plug-in unit is operated in its chopped mode. The blanking voltage can be applied to the CRT cathode by means of a switch located at the rear of the oscilloscope.

OTHER CHARACTERISTICS

AMPLITUDE CALIBRATOR provides 18 squarewave voltages at the front panel. Peak to peak amplitude from 0.2 mV to 100 V is in 1-2-5 sequence and accurate within 3%. Squarewave frequency is approximately 1 kHz.

OUTPUT WAVEFORMS available at the front panel include 2 positive gates of approximately 20 V, 2 positive-going sawtooths of approximately 150 V, and a delayed trigger of approximately 5 V.

POWER REQUIREMENT—A separate unit supplies power to the Type 555 Indicator Unit through an inter-unit cable. Wired for 117 V, 50 to 60 Hz, the electronically-regulated power supplies permit a line-voltage variation between 105 and 125 V. Changing transformer taps permits operation at 107, 127, 214, 234, or 254 V. All heaters in the indicator unit and amplifier heaters in the power supply are regulated for stable operation and long tube life. The Type 555 draws 1050 watts, maximum.

INDICATOR UNIT is 20 $\frac{1}{8}$ " high by 13 $\frac{1}{8}$ " wide by 24" deep. Net weight is 66 pounds. Shipping weight is 89 pounds, approx.

POWER SUPPLY UNIT is 10 $\frac{3}{8}$ " high by 13 $\frac{1}{2}$ " wide by 17 $\frac{1}{2}$ " deep. Net weight is 50 $\frac{1}{4}$ pounds. Shipping weight is 61 pounds, approx.

TYPE 555, without preamplifier plug-in units . . . \$2650

Each instrument includes: 1—Type 21A Time-Base Plug-In Unit; 1—Type 22A Time-Base Plug-In Unit; 4—P6006 probe (010-0127-00); 1—Inter-unit cable (012-0032-00); 1—Power Supply for Type 555; 1—Time base extension (013-0013-00); 1—3 to 2-wire adapter (103-0013-00); 1—3-conductor power cord (161-0010-00); 1—Smoke gray filter (378-0567-00); 1—Plate, Protector, CRT, clear (387-0918-00); 2—Patch cord, BNC-to-BNC, 18" (012-0087-00); 1—Patch cord, BNC-to-banana plug, 18" (012-0091-00); 1—Post jack, BNC (012-0092-00); 2—Instruction Manual (070-0403-00).

EXTRA TIME-BASE PLUG-IN UNITS

Net weight of each Type 21A and Type 22A Time Base Unit is 4 $\frac{1}{4}$ pounds, shipping weight of each is 6 pounds, approx.

TYPE 21A TIME-BASE UNIT \$275

TYPE 22A TIME-BASE UNIT \$285

U.S. Sales Prices f.o.b. Beaverton, Oregon

Please refer to Terms and Shipment, General Information page.

555 Discussion

Summarize Messages Sort by Date

#25038 From: David Gravereaux <davygrvy@...>

Date: Wed Dec 13, 2006 12:05 pm

Subject: 1A4 in a 555? dvygrvy

I was wondering why the 1A4 Quad channel plugin can't be used with the 555?

--

David Gravereaux <davygrvy@...>

Reply | Forward

#25040 From: Stefan <magnetron@...>

Date: Wed Dec 13, 2006 2:20 pm

Subject: Re: 1A4 in a 555? gyrotron2003

Offline

Send Email

Hi David,

the 1A4 should work in an 555.

There could be an issue with one supply line at the interconnecting plug as long as you have a 555 serial number below 7000.

If you have timebases 21A and 22A up to my knowledge everything works fine.

I do not have an 1A4 plugin but the manual for it mentions operation in the 555.

With the 1A1 its the same according to its manual and this one works fine in my 555.

However you should bear in mind that four traces on the dual beam scope plus the display from the other vertical compartment might be a bit too much in terms of usability. You have some 6 divisions of useful display for each vertical compartment. Should you intend to use the channels separately, two 1A2 or 1A1 might suit better.

To my knowledge you can try the 1A4 in your 555 without any danger. Someone correct me if I was wrong in this case please.

555 Discussion

Regards,

Stefan Junghans

> Hi,

>

> I was wondering why the 1A4 Quad channel plugin can't be used with the 555?

Reply | Forward

#25041 From: "arthurok" <arthurok@...>

Date: Wed Dec 13, 2006 2:22 pm

Subject: Re: 1A4 in a 555? arthurok_2000

Send IM

Send Email

you have to flip the switch on the back of the plug in to the proper position for use in a scope without display switching "it was designed to be used in a 547" i own a 1a4 and use it in my 547

Reply | Forward

#25054 From: "Larry Christopher" <tektronix@...>

Date: Wed Dec 13, 2006 6:56 pm

Subject: Re: 1A4 in a 555? scoper796

Offline

Send Email

If you tune to my website, you will see a couple of pictures of a 555 "making bacon, eggs, toast and coffee" with a 1A4 plugin.

http://www3.telus.net/harley_davidson/555-1A4-1.jpg

http://www3.telus.net/harley_davidson/555-1A4-2.jpg

I often wonder where people get the information to make a statement like "so and so won't work with such and such." It certainly isn't from

555 Discussion

the literature, the manuals, or an expert.

For those of you who wish to know more, there is no "alt trace sync" from the 551, an older and different beast. It will not work properly with the 1A4 and other plugins requiring alt trace.

Larry Christopher
www.theoscilloscopestore.com

Reply | Forward

#25137 From: "Stan and Patricia Griffiths" <w7ni@...>

Date: Sat Dec 16, 2006 5:33 pm

Subject: RE: Re: 1A4 in a 555? w7ni

Offline

Send Email

Hi Larry,

I did some research and found out some stuff about using multi-channel plugins in a 551. The 551 DOES have alternate sync capability. What it does not have is Chopped Transient Blanking. You can use the 1A4 and other multi-trace plugins in a 551. There was a mod kit (040-0398-00) for 551 s/n 101-5953 that improved the alternate trace performance of the 551 by changing V154 from a 6AU6 to a 6DJ8. Being a dual triode, the 6DJ8 feeds each vertical compartment separately with alternate trace switching pulses from the timebase instead of feeding them in parallel with the single 6AU6. There was never a mod kit to install chopped blanking in a 551.

Stan

555 Discussion

[Non-text portions of this message have been removed]

Reply | Forward

#25139 From: "Larry Christopher" <tektronix@...>

Date: Sat Dec 16, 2006 5:46 pm

Subject: Re: 1A4 in a 555? scoper796

Offline

Send Email

Thanks for the info Stan. Yes, I noticed that on one of the 551s I have here, and did some research but never actually field-tested my theories. The 1A2 does the same thing in a 551. It shouldn't be hard to add a blanking feed from the plugin, the 551 may have been on its way out by then anyway.

It is interesting to find that some plugins don't work in all scopes. One that comes to mind is the 532-S7. It has no decoupling resistors in the feeds of power to the plugins. If you put a CA in them they catch fire. Very disconcerting. Later the resistors were in the scope not the plugin.

Only 3 months to spring training...whoops...Puyallup.

Larry

Reply | Forward

#25138 From: "Stan and Patricia Griffiths" <w7ni@...>

Date: Sat Dec 16, 2006 5:48 pm

Subject: RE: Re: 1A4 in a 555? w7ni

Offline

Send Email

Hi Larry,

I thought this one needed some clarification too.

555 Discussion

555's s/n 101-7000 were supplied with 21 and 22 timebases.

555's s/n 7000-up were supplied with 21A and 22A timebases.

The 21A and 22A have the ability to choose triggering signals from either vertical plugin where the 21 and 22 do not. This all works fine in any 555 mainframe above s/n 7000 using 21A and 22A timebases. However, if you want to use a 21A or 22A in an early 555 (below s/n 7000), the mainframe needs to be modified by adding some coax cables to bring the plugin trigger signals up to each timebase compartment. There was a mod kit (040-0328-01) to do this.

There is no way to modify 21's and 22's to provide plugin triggering since it would require new trigger source switches with more positions and new front panels to show the new switch positions. Tek never made a kit to do this.

The 1A4 will work OK with any version of the 555 and timebase combinations. You just won't have plugin trigger source capability if you do not use 21A or 22A timebases (and a modified 555 mainframe if it is below s/n 7000.)

Stan

From: TekScopes@yahoogroups.com [mailto:TekScopes@yahoogroups.com]

555 Discussion

On Behalf

Of Larry Christopher

Sent: Thursday, December 14, 2006 12:42 PM

To: TekScopes@yahoogroups.com

Subject: [TekScopes] Re: 1A4 in a 555?

The reason is that there is a (potential) problem with the 1A4 plugin in certain 555s. These are ones with 21 and 22 (not 21A and 22A) plugins in the sweep in a 555 that has been modified for plugin triggering. This is covered prominently in the 1A4 and has probably led to confusion about this issue. The 1A4 will work in these but the scope needs a simple mod first.

Case closed.

Larry Christopher

Not so Stan, at least from the note in the 1A4 manuals. A modified 555 mainframe and 21 or 22 plugins will place a voltage on the trigger amplifier and connector.

Larry

Reply | Forward

#25155 From: "Stan and Patricia Griffiths" <w7ni@...>

Date: Sun Dec 17, 2006 8:39 pm

Subject: RE: 1A4 in a 555? w7ni

Offline

Send Email

I'll check it out, Larry. Thanks.

555 Discussion - #2

#25276 From: "faustian.spirit" <faustian.spirit@...>

Date: Fri Dec 29, 2006 1:15 pm

Subject: Bringing up a 555 faustian.spirit

Offline

Send Email

Hi all,

recently got my hands on a 555 System in unknown working condition (probably been stored 10+ years). Can anybody here give me good hints from experience on bringing this up without risking unnecessary damage?

Especially, can the PSU (these things are [expletive deleted] heavy!) be bench-tested separately, or will there be unexpected effects (underload)? I am aware that I will probably need to take out and reform all the lytics....

What happens if I operate the unit with only one vertical, or only one horizontal, or one only each...? Don't want to switch on and fry everything in one session :)

I can work on the verticals with the 545B (doing so at the moment... an extender cable would help with the Type D, it would.... I'd rather avoid turning the scope on its side... oh well...)... BTW, does anyone of the history buffs here know why a Type L has such a big honking filter cap on board?

Oh, and BAMA does not have any 21A/22A schematics... oh well again...

And finally... what ARE the differences between different serial numbers of the PSU? It is often claimed they are not interchangeable... why?

Cheers,

Andy

Reply | Forward

#25281 From: "Larry Christopher" <tektronix@...>

555 Discussion - #2

Date: Fri Dec 29, 2006 3:00 pm

Subject: Re: Bringing up a 555 scoper796

Offline

Send Email

Hi Andy,

I will try to help you with some of your questions:

> Especially, can the PSU be bench-tested separately, or will there be unexpected effects (underload)?

You will have an unexpected effect - it won't work. The AC for the power supply, as well as its filament supply, comes from the 555.

I am aware that I will probably need to take out and
> reform all the lytics....

No reason to do this, these do not give a problem.

>

> What happens if I operate the unit with only one vertical, or only one

> horizontal, or one only each...? Don't want to switch on and fry

> everything in one session :)

Should be no problem, one beam will be weird but no damage.

> Oh, and BAMA does not have any 21A/22A schematics... oh well again...

These are in the 555 manual. Get the correct manual.

>

> And finally... what ARE the differences between different serial

> numbers of the PSU? It is often claimed they are not

> interchangeable... why?

555 Discussion - #2

Different serial number ranges used different AC wiring. Best to use the PSU that came with the scope originally. Same with the 551.

Larry Christopher
www.theoscilloscopestore.com
Home of The Fridge!

Reply | Forward

#25284 From: "Stan and Patricia Griffiths" <w7ni@...>

Date: Fri Dec 29, 2006 5:42 pm

Subject: RE: Bringing up a 555 w7ni

Offline

Send Email

Hi Andy,

Others may call me careless in my approach to firing up an old 555, but I would just plug it in and turn it on. It is pretty well fused and I would not expect any to blow anyway.

You can not test the power supply disconnected from the scope and your reason is correct. It must have a proper load on it and, yes, you will need all plugins in place to put a proper load on the power supply. Both timebases and both verticals.

On old Tek scopes, I never bother to reform the electrolytics. A shorted one is very rare and an open one will show up as too much ripple somewhere. I have never seen a shorted one do serious damage.

Over the past 46 years, I have probably turned on more than 1000 of these old scopes. I have lost count but I have at least six or seven 555's in my collection . . . maybe more.

I think when originally shipped from the factory, the serial number of the power supply will match the serial number of the mainframe. Sometimes in the field, mainframes and power supplies get swapped around, but I can't remember any serious incompatibility problems, even with mismatched serial numbers.

555 Discussion - #2

Stan

[Reply](#) | [Forward](#)

#25319 From: "Stan and Patricia Griffiths" <w7ni@...>

Date: Sat Dec 30, 2006 7:10 pm

Subject: RE: Re: Bringing up a 555 w7ni

Offline

[Send Email](#)

Hi Andy,

You asked about connectors for extender cables. There are three possible extenders you could be talking about: 1) vertical plugin, 2) timebase plugin, 3) power cable from mainframe to power supply. I am sure I have connectors that I can sell you to build extenders for either type of plugin for a couple of dollars per connector. Most of what I have have been salvaged but are still perfectly useable. In the Tektronix Service Center we had an extra long power supply cable that made it much easier to turn the 555 on its side for maintenance. Let me know if you need some connectors to make extenders.

You also asked me how many old scopes "blew up" :-)) on turn on. No explosions that I can recall, but some came quietly on but did not work completely.

Stan

[Reply](#) | [Forward](#)

#25323 From: "coresta" <coresta@...>

Date: Sun Dec 31, 2006 12:52 am

Subject: RE: Re: Bringing up a 555 vector525

555 Discussion - #2

Offline
Send Email
Hi Stan,

As i see this new thread, i always asked myself about the use of Kalotron in the PSU of the 555 ? What's the big iron potted case too ?

Pierre

Reply | Forward
#25330 From: "Larry Christopher" <tektronix@...>
Date: Sun Dec 31, 2006 10:29 am
Subject: Re: Bringing up a 555 scoper796
Offline
Send Email

The 555 power supply uses that big heavy saturable reactor to regulate the heater voltages. It relies on a little tube that varies its conductivity according to the temperature of its filament and varies the control current in the reactor, which in turn regulates the heater supply transformers primary voltage.

And you are correct, the 551 did not have this arrangement.

Bonne Noel.

Larry Christopher

Reply | Forward
#25331 From: "Stan and Patricia Griffiths" <w7ni@...>
Date: Sun Dec 31, 2006 7:28 pm
Subject: RE: Re: Bringing up a 555 w7ni
Offline
Send Email
Hello Pierre,

555 Discussion - #2

If I remember right, the big iron potted case contains a device is called a "saturable reactor" (or something like that) and is used to regulate the AC voltage applied to the vertical amplifier tubes. I think this was an attempt to minimize the effects of cathode interface which looks like a spike on the leading edge of a fast-rise square wave. Actually, it is a DECREASE in low frequency gain of the vertical amplifiers.

In a scope without regulated filament voltage, cathode interface is always worse at low line voltages which means lower filament voltage and therefore, lower filament temperature. If you observe a fast-rise square wave while you lower the line voltage on a scope with bad cathode interface, the leading edge spike seems to grow over about one minute of time. If you look very carefully, it is actually the trailing edge, or flat portion of the square wave, that is DECREASING in amplitude over time as the filaments cool down. You can verify this by simply plugging in the scope calibrator and watching the gain of the vertical change as the calibrator signal appears to decrease in amplitude. No spike seems to grow on the leading edge because there are no high frequency components in the scope calibrator signal.

There is actually a filament voltage adjustment in the 555 power supply and the list of equipment needed to calibrate a 555 includes an iron vane AC voltmeter to accurately set the AC filament voltage. I think the 517 is the only other scope Tek made that has adjustable filament voltage . . . but I could be wrong about this since it has been years since I looked at my 517's.

Stan

Reply | Forward

#25297 From: "morrison2002" <vilgotch@...>

Date: Sat Dec 30, 2006 3:50 am

Subject: Re: Bringing up a 555 morrison2002

Offline

Send Email

Hi Andy,

I have sent you the 21A/22A manual extract off list.

555 Discussion - #2

I'm not sure what you mean by the big honking filter cap in the L. It certainly has quite comprehensive decoupling of the B+ to the low level amps which is pretty standard practice. I'm too lazy to get out my L to check, but that's almost certainly what it's for. That quite a high gain wideband amplifier and keeping such devices stable is not a trivial design task!

Good luck with your scoposaurus, it's worth the effort

Morris

[Reply](#) | [Forward](#)

#25311 From: "Larry Christopher" <tektronix@...>

Date: Sat Dec 30, 2006 1:12 pm

Subject: Re: Bringing up a 555 scoper796

Offline

[Send Email](#)

This is not for filtering. The L manual says:

"Low-frequency peaking for the X10 amplifier is provided mainly by C6002A and C6002B in the plate circuits of V5942 and V6042. With their associated resistors, these capacitors form a low-frequency boost network to compensate for the low-frequency attenuation introduced in the cathode circuits, the screen circuits, and the RC coupling network between the Second amplifier and the Second cathode follower. ... the amount of attenuation can be varied with the LOW FREQ. ADJ. control in the grid of V6132."

This technique is discussed in detail in "Typical Oscilloscope Circuitry."

[Reply](#) | [Forward](#)

#25351 From: "Stan and Patricia Griffiths" <w7ni@...>

Date: Tue Jan 2, 2007 12:37 am

Subject: RE: Re: Bringing up a 555 w7ni

555 Discussion - #2

Offline
Send Email
Hi Arthur,

It isn't really what I believe that counts here. I was just repeating what Tektronix has written in the service manual for 555 required equipment. I think they specify an Iron vane movement because the saturable reactor distorts the waveform as it regulates the filament voltage. We had iron vane meters (0-10 VAC) specifically to make this adjustment in each Tektronix Service Center and they have been assigned the Tektronix Part Number 067-0514-00 so some engineer at Tek must have thought it was important. That was many years ago and maybe modern true reading rms voltmeters are up to the job today.

Stan

From: arthurok [mailto:arthurok@...]
Sent: Sunday, December 31, 2006 6:36 PM
To: 'coresta'; Stan and Patricia Griffiths
Cc: TekScopes
Subject: Re: [TekScopes] Re: Bringing up a 555

you believe the crest factor is so high that a modern true rms multimeter wouldnt do the job?

Reply | Forward
#25352 From: "arthurok" <arthurok@...>
Date: Tue Jan 2, 2007 2:13 am
Subject: Re: Re: Bringing up a 555 arthurok_2000

555 Discussion - #2

Send IM

Send Email

iron vane meters are still being manufactured for panel meter applications.

"simpson electric and other manufactures" they are genuine true rms responding.

a simpson 260 multimeter is not true rms responding .

most non harmonically neutralized constant voltage transformers have distorted output waveforms too

the note that the output waveform is non sinusoidal is very important sir.

i have a tek thm420 scope meter and its very usefull for looking at waveforms to see what they are really like and for checking power supply ripple.

mine was an exchange through tek.

the one i purchased through ebay was never modified by tek .

"safety recall"

it replaces a tek 214 scope i had.

i like a scope that can measure frequency and voltage accurately on screen.

my 7d15 stays in my 7904 next to a 7b92a for most measurements i make.

I think their frequency response is somewhat limited (kHz), and of course they are nonlinear and lack sensitivity at the beginning of the travel, but otherwise they are great. I keep several for measuring odd shaped stuff.

Compare different meters on odd shaped signals when you get the chance, you'll be surprised how little truth some cheap "true RMS" meters really show. I'm not saying low quality meters are useless, but one must always be aware when the tool is used outside it's capabilities.

Anyone using tek multimeters?

ST

555 Discussion - #2

[Reply](#) | [Forward](#)

Untitled

Tektronix 555 o'scope problem.

Posted: Jan Thu 21, 2016 12:53 am

The upper beam on this scope will only sweep unless set to trigger from the lower beam time base. I have tested all the upper time base tubes and all good. The supply voltages checked as per the Tek schem. for the time base seem to be fine. There is a "sawtooth out" jack on the front of the upper time base and from what I'm seeing using the working trace, there is no sawtooth waveform there. I only have this scope to check that with. Before I dig into it further, thought I'd ask you fellows here if you've had any experience with this. Been many years since I've worked electronic problems. Thank for any time and advice.

Garrett

Re: Tektronix 555 o'scope problem. PostPosted: Jan Thu 21, 2016 7:12 am

Member

User avatar

Forgive me, Garrett, but... I'll bet you a donut to a steak dinner that this is an operator malfunction.

Triggering on the 555 is VERY complicated.

Assuming you have the 21A and 22A timebase modules...

Set the controls on both modules as follows:

Trigger VERNIER (red knob) dot at 12 o'clock

Trigger LEVEL +

SLOPE +

COUPLING AC

SOURCE Line

Untitled

SWEEP FUNCTION Normal

TIME/CM 0.1 SEC (a full-width trace takes 1 second)

VARIABLE (red knob) fully clockwise to detent

Set the UPPER BEAM and LOWER BEAM controls as follows:

FOCUS dot at 12 o'clock

INTENSITY fully counter-clockwise

HORIZ. POSITION (red knob) dot at 12 o'clock

HORIZ. DISPLAY TIME BASE A X1

I don't know what vertical amps you have. It doesn't matter.

If multi-channel, set for Channel A (or 1).

COUPLING AC

VOLTS/CM 1 volt/CM

VARIABLE (red knob) fully clockwise

POLARITY Normal or+

VERTICAL POSITION dot at 12 o'clock

Turn the 'scope on and let it warm up for a couple of minutes...

Observe the four neon lamps on the right side of the UPPER BEAM control area.

The lower pair should be alternating, with the top one on for half a second then the bottom one on.

If either of the upper pair is on, rotate the VERT POSITION control on the left V plugin so they're both off.

At this point you have a trace moving across the middle of the screen, but you can't see it.

Rotate the UPPER BEAM INTENSITY control clockwise until you see the trace.

Adjust focus as needed. There may be some interaction with the INTENSITY control.

You can move the trace up and down on the screen using the V POS control on the left module.

Untitled

On TIME BASE A rotate the TIME/CM switch to different positions to confirm it's controlling the beam.

Return the UPPER BEAM INTENSITY control to its fully clockwise position (trace not visible).

Repeat all steps after 'scope turn-on with the LOWER BEAM controls to the right of the CRT.

As currently configured this will use TIME BASE A and the right-hand vertical module.

You can check TIME BASE B using the same procedure but with the HORIZ. DISPLAY sources set to TIME BASE B x1.

That's enough for the moment. If all those tests are successful, we'll get into the complicated stuff.

- Leigh

73 de Leigh W3NLB

<http://www.AtwaterKent.info>

Click "Grebe Stuff" for Synchrophase info

Re: Tektronix 555 o'scope problem.PostPosted: Jan Thu 21, 2016 3:22 pm

Leigh, it could very well be operator error and I'll try your setup instructions this aft. when I'm back home and report here. MM, the upper beam has a type 21 timebase and the lower beam has a type 22. Thanks to both of you.

Re: Tektronix 555 o'scope problem.PostPosted: Jan Thu 21, 2016 4:38 pm

That machine is extremely versatile, which is both a major selling point and a usage challenge. I suggest that your

Untitled

highest priority must be protecting the CRT, being careful not to burn it. Always keep the intensity turned down unless you're actually using a particular beam. Don't ever turn it up trying to find the beam. Use the neon bulbs to show you where it is.

- Leigh

Re: Tektronix 555 o'scope problem. PostPosted: Jan Fri 22, 2016 4:24 am

From the sound of things you have one side of the balance driver dead in the timebase. You might be able to identify the problem without an extender, but I doubt it.

- Leigh

555 - Kalotron 2AS-15A temp limited diode

Hi all, Roy Morgan asked me to describe the 2AS-15 I was looking for, and by the time I had finished typing all this I thought the rest of you might like to read it too. > >special diode type 2AS-15 > > What is the nature of the 2AS-15? I have a little 7-pin tube with a > semi-cylindrical "plate" and a D-shaped electrode at the bottom of it.. > numbers not readable now.. maybe thats it?? > > Anyway, describe this oddity for me. It's an interesting device. It's an octal GT sized bulb which contains a little directly heated diode mounted horizontally in the tube. The plate is tubular and about 1.5 cm long and a couple of mm in diameter. Running down the middle is a single thin wire filament under spring tension. The spring is arranged so that if the filament breaks a couple of rods snap together and short the diode. There's also a separate jumper between a couple of base pins like in an octal VR tube. In operation the filament is energized from the 'scope's heater supply via an adjusting pot. The plate current of the diode is passed through a resistor network which controls the bias on a 6CZ5 power tube. The plate current of the 6CZ5 in turn controls a saturable reactor (or magnetic amplifier) which regulates mains voltage to the primary of the heater transformer, which has 11 6.3 volt secondaries. The jumper in the tube is connected to ensure that the regulating circuit is disabled and won't turn the heater voltage up to full blast if the 2AS15 is removed. Likewise, if the filament burns out, the diode is shorted so the regulator doesn't get the wrong message and burn out all the heaters in the 'scope (62 tubes plus an absolutely irreplaceable monster double beam CRT). The reason for all this is that mains variations have an unpredictable effect on scope operation. It seems more pronounced in the 555 than other Tek scopes I have for some reason, maybe because of the huge number of tubes and high total heater current. The whole scope draws about a kilowatt! At my QTH here in summer the mains is likely to vary more than 10% some days when everyone in the street has their air conditioning on. Because the magnetic amplifier distorts the sinusoidal mains waveform, the feedback controller needs to sense the true RMS value of the heater voltage, hence the thermionic method using a

555 - Kalotron 2AS-15A temp limited diode

diode. It's very nifty! I'd be interested to know whether this device was used in any other BAS or whether it was specially made for Tek. 73 de Morris VK3DOC ----- End of BOATANCHORS Digest 2745

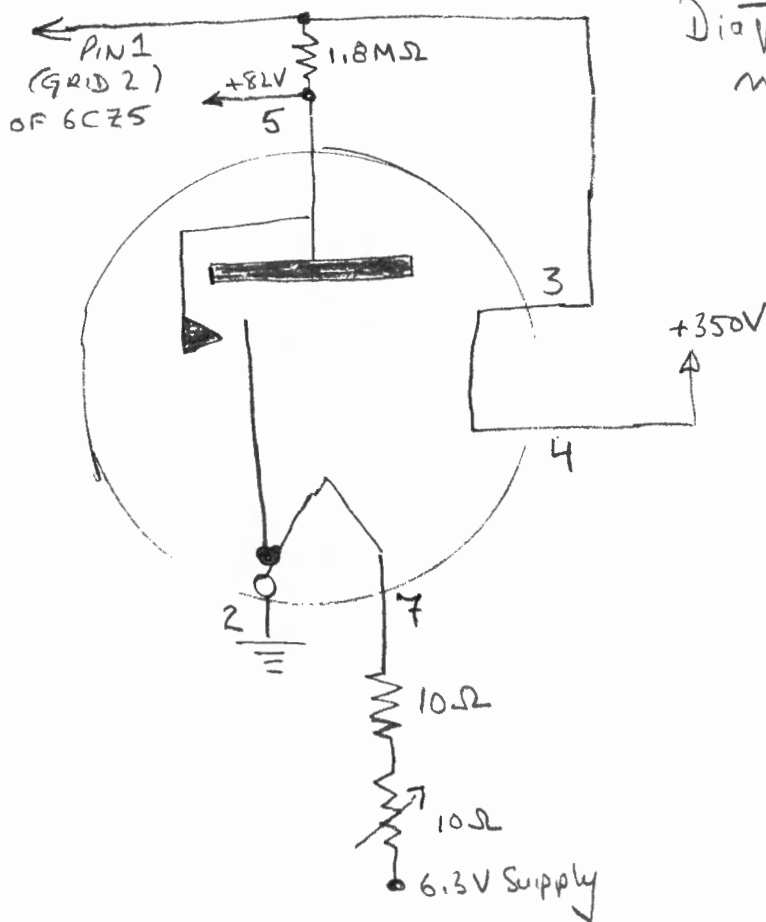
From: JACK Iverson this is re the 2AS-15 tube. this was originally used in an old sorensen power supply to regulate a rectifier transformer. mebbe 40 years ago. All of the tubes that I have are "sorensen" jack Jack Iverson K0EWU jackiv@juno.com ARRL, IEEE LM, RCA, AMI, ARCI, QCWA,CCA

----- Message-Id:

<199912060138.UAA20895@flash.naxs.net> From: "Barry L. Ornitz" To: Old Tube Radios Subject: Re: Tubes for Tek 555 Date: Sun, 5 Dec 1999 20:38:17 -0500 Morris Odell wrote: >Roy Morgan asked me to describe the 2AS-15 I was looking for, and by the >time I had finished typing all this I thought the rest of you might like to >read it too. >> >special diode type 2AS-15 I am not familiar with this particular tube type, although from the description I have seen a similar tube used in an AC voltage regulator used to power an old large electron microscope system. These tubes are operated in the temperature-limited region where their emission is exponentially related to the cathode temperature. The plate voltage used is high enough that the tube current is totally controlled by the filament temperature. A pure tungsten filament is used here, thoriated and oxide-coated cathodes are not suitable here. Typical operation of such tubes is at an operating point where the plate current is approximately proportional to the RMS filament voltage to the 8th to the 12th power. Thus minor variations in filament voltage produce quite large changes in plate current. An amplified signal proportional to this current is used to control the saturable reactor. I have also seen similar circuits controlling the motor drives on motor-driven variable transformers. The more common use of such temperature-limited diodes is as controlled noise generators. The Sylvania 5722 is such a diode. Electrons are emitted from the cathode carrying discrete charges, but the current fluctuates in a

555 - Kalotron 2AS-15A temp limited diode
 random way about the mean. In the voltage regulator application, only this
 mean current is used. But in a noise generator, the statistical variations
 about this mean are what are used. In the temperature-limited regime, the
 RMS fluctuation of the current measured over a frequency band is directly
 proportional to the average current. So by measuring the average current,
 the noise output of the tube is known. The noise output is varied by
 adjusting the filament voltage. Typical use of these noise generators is
 for measuring receiver sensitivity and noise figure. 73, Barry L. Ornitz

WA4VZQ ornitz@tricon.net -



V798
 Diagram from Tektronix 551
 manual schem. 11

Tube labelled
 Kalotron 2AS15A
 THERMOSEN, INC
 STAMFORD, CONN.
 see Carton for
 Patent info!

TYPE 555 DUAL-BEAM OSCILLOSCOPE — FAILURE OF INTENSITY CONTROL TO TURN OFF BEAM

Sum
Sec
1965
Oct 17

The Type 555 Oscilloscope has two INTENSITY controls—one for the Upper Beam and one for the Lower Beam. Inability of one of these controls to turn off its associated beam may be caused by failure of the type 5642 vacuum tube in the INTENSITY control's circuit. Schematic designation of this tube is V822 in the Upper Beam's INTENSITY control circuit or V922 in the Lower Beam's INTENSITY control circuit. Replacement of the defunct 5642 tube will generally clear up the problem.

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CRT to Instrument

Cross Reference Database



Tektronix model 555 can accept the following CRTs:

CRT	Phosphor	Remarks
154-0199-00	KP2	OLD STANDARD
154-0219-00	P1	
154-0220-00	P7	
154-0221-00	P11	
154-0298-00	P15	
154-0303-00	P16	
154-0328-00	P5	
154-0333-00	P19	
154-0353-00	P31	STANDARD
154-0394-00	P32	
154-0425-00	P2	INTERNAL SCALE, OLD STANDARD
154-0436-00	P7	INTERNAL SCALE
154-0437-00	P11	INTERNAL SCALE
154-0438-00	P31	INTERNAL SCALE, STANDARD
154-0476-00	P2	INTERNAL SCALE
154-0476-01	P7	INTERNAL SCALE, OLD STANDARD
154-0476-02	P11	INTERNAL SCALE
154-0476-03	P31	INTERNAL SCALE, STANDARD
154-0775-00	P31	INTERNAL SCALE
154-0775-03	P7	INTERNAL SCALE
154-0775-04	P11	INTERNAL SCALE
154-0776-00	P31	
154-0776-03	P7	
154-0776-04	P11	

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Last modified on 2/29/00 11:22:58 PM

555 made thru _____
 (last full page in 1967 Catalog) #2650
 Ltd demand in 1968 + 1969
 Catalogs

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CRT Phosphor Characteristics

Reference Data

[P1 through P12](#)[P13 through P24](#)[P25 through P35](#)

Type	Fluorescence	Phosphorescence ¹	Relative Luminance ²	Relative Writing Speed ³
P1	Yellowish-Green		45	35
P2 *	Bluish-Green	Green	60	70
P3	Greenish-Yellow		45	15
P4	White		50	75
P5	Blue		3	15
P6	White		70	25
P7 *	Blue-White	Yellow-Green	45	95
P8 *	Obsolete - Replaced by P7			
P9	JEDEC Registration Withdrawn			
P10	Dark Trace Storage - Not Luminescent			
P11	Purplish-Blue		25	100
P12 *	Orange		18	3

¹ Where different than Fluorescence.

² Taken with Spectra Brightness Spot Meter which incorporates CIE standard eye filter.
Representative of 10KV aluminized screens.

³ Taken with 10,000 ASA Polaroid film for 10 KV aluminized screens.

* Phosphors having low level decay lasting over one minute under conditions of low ambient illumination.

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Last modified on 2/29/00 11:10:26 PM

Ip (mA)		CT Max (PF)	Case Style ³	JEDEC or Mfr Number	Part Number	Used in Instrument	Package style	
Min	Max						DO17	Top hat
0.9	1.1	10	DO-17	STD962	152-0169-00	L140, L20, L30, 067-0518-00, 067-0594-00, 1L60, 1S2, 1503, 3B5, 3T7, 4054, 4054A, 4902, 5S14N, 7S14, 7T11	DO18	GE48
0.975	1.025	5	DO-17	STD933	152-0181-00	1S2, 221, 422	DO20	Like 7T11
	1	10	A82a	1N3712	152-0189-00	L20, L30	M83	RCA1
	2.2	25	DO-17	STD931	152-0402-00	RM546, RM547, R556, SPG11, SPG12, 1401, 1401A, 283/R, 3B2, 3B3, 422, 491, 546, 547, 556	M214	same as DO18
	2.2	25	DO-17	STD930	152-0330-00	323, 324	A82	Top hat
	2.2	25	DO-20	TD202	152-0155-00	RM546, RM547, 546, 547	A82A	Top hat
	2.2	25	A82	1N3714	152-0081-00		A293	?
	4.7	6	DO-18	TD252	152-0214-00	1S1	TO18	same as transi
	4.7	18	DO-17	STD704	152-0125-00	RM546, RM547, R148, R544, R556, 1L40, 1S1, 11B1, 11B2, 11B2A, 147/R, 147A/R, 1470, 148, 148M, 149/R, 149A/R, 21A, 22A, 3B4, 3B5, 408, 432/R, 434/R, 453/R, 453A/R, 454/R, 464, 465, 466, 491, 5T3, 544, 546, 547, 556, 7B70, 7B71, 7D11		- for pkg
	4.7	18	DO-17	STD704	152-0125-01	335, 464, 465, 465B, 466		
	4.7	25	A239	TD717	152-0378-00			
	4.7	50	DO-17	STD932/TD716	152-0373-00	R564B, TEK31, 1S2, 115, 564B		
	4.7	50	DO-17	STD736	152-0093-00			
	4.7	50	DO-18	1N2841	152-0063-00			
	5	7	A239		152-0376-00			
	5	15	A239	38769/STD917	152-0381-00			
	5	15	M-83	1N3128	152-0074-00			
4.75	5.3	7	DO-17	STD910	152-0310-00	454/R, 454A/R		
	10	6	TO-18	XF1A510	152-0041-00			
	10	8	A239		152-0371-00			
	10	8	M-83	1N3848	152-0140-00	RM585A, S53, 581A, 585A, 7B52		
	10	9	M-214	SMDT841	152-0154-00	RM546, RM547, R544, R556, TU5, 1S1, 1S2, 21A, 22A, 544, 546, 547, 556, 7B70, 7B71		
10		90	DO-17	STD916	152-0098-00	RM565, 556, 565, 661		
	10	25	DO-17	STD927	152-0386-00	OS261, 475/R, 7B50, 7B51		
	10	25	M-83	SMTD604	152-0073-00			
	10	28	A82	ST0615	152-0102-00	TU5, 581, 585		
	10	50	DO-17	1N3719Fmly/STD964	152-0182-00	422, 661, 7B92, 7B92A		
9	11	4.7	DO-17	SMTD994	152-0177-01	S53, 067-0587-01, 067-0580-00, 3T5, 3T6, 485, 5S14N, 7D14, 7T11, 7T11A		
9	11	8	DO-17	SMTD995	152-0140-01	RM546, RM547, RM585, R544, R556, R7912, S51, S52, TU5, 067-0572-00, 067-0572-01, 067-0681-00, 1S1, 1S2, 1502, 21A, 22A, 3T5, 3T6, 475/R, 475A/R, 475M, 544, 546, 547, 556, 581A, 585A, 7B52, 7B53N, 7B70, 7B71, 7D10, 7D11, 7T11, 7T11A		
9	11	3	DO-17	SMTD998	152-0177-02	067-0681-01, 485/R, 7B92, 7B92A		
	20	4	M-83	32623	152-0203-00	3T77, 3T77A, 5T1A, 519		
	20	4	M-83	37181	152-0159-00	519		
	20	4	DO-20	37181	152-0156-00	RM546, RM547, R544, 544, 546, 547		
	20	4.5	DO-17	SMTD914	152-0387-00	S51, 3T77A		
	20	10	DO-17	SMTD912	152-0379-00	S50		
	20	20	A239	38820/SMTD903	152-0380-00	3T77A		
	20	20	M-83	1N3129	152-0043-00			
	21	1.5	DO-20	SMTD892	152-0329-00	284, 7T11, 7T11A		
16.8	50	1		SMTD910/SMTD636	152-0377-00			
	50	1.2		SMTD961	152-0507-00			
	50	1.5	DO-20	SMTD898	152-0383-00	S51, S52		
	50	3			152-0382-00			
	50	5		SMTD907	152-0275-00	280, 661		
	50	6		TD1081	152-0365-00			
	50	6	M-83		152-0334-00	661		
	50	6			152-0334-01	661		
	50	6			152-0099-00	280, 661		
	50	6	M-83	TD1081	152-0078-00			
	50	25	M-83	1N3130	152-0253-00			
	50	5		SMTD714	152-0254-00			
	100	6		SMTD716	152-0254-01	067-0513-00		
	100	6		SMTD716	152-0225-00	146		
	100	6	M-214	TD256	152-0266-00			
	100	35	M-214	TD256	152-0375-00	1S2		
	100	40	DO-17	SMTD908	152-0277-00	1S2		
	100	40	M-83	37650				

	P/N	Used in
	152-0098-00	RM565, 556, 565, 661
	152-0099-00	280, 661
	152-0102-00	TU5, 581, 585
4.7	152-0125-00	RM546, RM547, R148, R544, R556, 1L40, 1S1, 11B1, 11B2, 11B2A, 147/R, 147A/R, 1470, 148, 148M, 149/R, 149A/R, 21A, 22A, 3B4, 3B5, 408, 432/R, 434/R, 453/R, 453A/R, 454/R, 464, 465, 466, 491, 5T3, 544, 546, 547, 556, 7B70, 7B71, 7D11
	152-0125-01	335, 464, 465, 465B, 466
10.0	152-0140-00	RM585A, S53, 581A, 585A, 7B52
11.0	152-0140-01	RM546, RM547, RM585, R544, R556, R7912, S51, S52, TU5, 067-0572-00, 067-0572-01, 067-0681-00, 1S1, 1S2, 1502, 21A, 22A, 3T5, 3T6, 475/R, 475A/R, 475M, 544, 546, 547, 556, 581A, 585A, 7B52, 7B53N, 7B70, 7B71, 7D10, 7D11, 7T11, 7T11A
10.0	152-0154-00	RM546, RM547, R544, R556, TU5, 1S1, 1S2, 21A, 22A, 544, 546, 547, 556, 7B70, 7B71
2.2	152-0155-00	RM546, RM547, 546, 547
20.0	152-0156-00	RM546, RM547, R544, 544, 546, 547
	152-0159-00	519
1.1	152-0169-00	L140, L20, L30, 067-0518-00, 067-0594-00, 1L60, 1S2, 1503, 3B5, 3T7, 4054, 4054A, 4902, 5S14N, 7S14, 7T11
	152-0177-01	S53, 067-0587-01, 067-0580-00, 3T5, 3T6, 485, 5S14N, 7D14, 7T11, 7T11A
	152-0177-02	067-0681-01, 485/R, 7B92, 7B92A
	152-0177-03	067-0681-01
	152-0181-00	1S2, 221, 422
10.0	152-0182-00	422, 661, 7B92, 7B92A
1.0	152-0189-00	L20, L30
	152-0203-00	3T77, 3T77A, 5T1A, 519
	152-0214-00	1S1
	152-0225-00	146
	152-0254-00	N/A
	152-0254-01	067-0513-00
	152-0266-00	N/A
	152-0275-01	280, 661
	152-0277-00	1S2
	152-0310-00	454/R, 454A/R
	152-0329-00	284, 7T11, 7T11A
	152-0330-00	323, 324
	152-0334-00	661
	152-0334-01	661
	152-0365-00	N/A
	152-0371-00	N/A
4.7	152-0373-00	R564B, TEK31, 1S2, 115, 564B
	152-0375-00	1S2
	152-0376-00	N/A
	152-0377-00	N/A
	152-0378-00	N/A
	152-0379-00	S50
	152-0380-00	3T77A
	152-0381-00	3T77A
	152-0382-00	N/A
	152-0383-00	S51, S52
	152-0386-00	OS261, 475/R, 7B50, 7B51
	152-0387-00	S51, 3T77A
2.2	152-0402-00	RM546, RM547, R556, SPG11, SPG12, 1401, 1401A, 283/R, 3B2, 3B3, 422, 491, 546, 547, 556
	152-0507-00	N/A

Tek Diode Usage